APPENDIX B
CALCULATIONS FOR WATER QUALITY OBJECTIVE ALTERNATIVES

The calculations used to determine the concentration for each Alternative are presented in order of increasing complexity. Therefore, calculations for Alternatives 3 and 5 are discussed before the discussion of the calculations used to determine Alternative 2 and 4 numerical objectives. No calculations are needed for Alternative 1, which would establish no numeric water quality objective for the Delta.

Calculation of Alternatives for Large Fish

The following equation was used by USEPA for calculation of the recommended fish-tissue based methylmercury water quality criterion (USEPA, 2001). It is the basis of calculation of the TL4 fish objectives in Alternatives 2-5.

Equation 1

$$\frac{\textbf{(RfD – Intake from other sources) * body weight}}{\textbf{Local fish consumption rate}} = \textbf{Acceptable level of MeHg in fish}$$

Where:

RfD = reference dose for humans, representing the safe, total daily intake of methylmercury (0.1 micrograms MeHg/kg body weight per day).

Intake from other sources = average intake of methylmercury from marine fish by adults in the general population (0.027 micrograms MeHg /kg body weight per day).

Body weight = average, adult human body weight (70 kg)

Alternative 3 assumes people are eating only locally caught TL4 fish and eating the national average commercial fish. Therefore, Equation 1 can be solved as written by inserting the appropriate consumption rate.

For Alternative 3:

$$\frac{(0.10\ \mu g/kg\text{-}day – 0.027\ \mu g/kg\text{-}day) * 70\ kg}{17.5\ g/day\ TL4\ fish} = 0.29\ \mu g/g\ MeHg\ in\ TL4\ fish\ (0.29\ mg/kg)$$

For Alternative 5:

Calculation of this objective also assumes an adult human body weight of 70 kg and a methylmercury reference dose of 0.1 μg/kg body weight per day. However, because intake of methylmercury is solely from locally caught Delta TL4 fish and there are no other intake sources (i.e. 0.027 μg/kg-day from marine fish), the equation used to calculate this alternative water quality objective for the corresponding higher consumption rate appears as:

$$\frac{(0.10\ \mu g/kg\ day) * 70\ kg}{142.4\ g/day\ TL4\ fish} = 0.05\ \mu g/g\ MeHg\ in\ TL4\ fish\ (0.05mg/kg)$$

For Alternative 2 and 4:

Large fish objectives in Alternatives 2 and 4 assume that people eat combinations of fish from trophic levels 3 and 4. Alternative 2 also include trophic level 2 fish. Calculation of these objectives required an additional step to determine the concentrations in the various trophic levels. Methylmercury concentrations in the higher trophic levels were put in terms of the concentration in the lowest trophic level. Staff then solved for the lowest trophic level concentration. To express the concentration in a higher trophic level fish, site-specific ratios of methylmercury concentrations between the trophic levels (TLRs) were used. Existing Delta fish concentration data were used to develop the ratios. The TLR between trophic levels 3 and 2 (TLR 3/2) is 4.5. The TLR between trophic levels 4 and 3 (TLR 4/3) is 2.9 (See Table 4.6 in the TMDL Report). Equation 2 is used to solve the concentrations in various trophic levels.

Equation 2

$$\textbf{Safe fish tissue level in all diet} = (\%\ \mathrm{dietTL}_2 * \mathrm{TL2}_{conc}) + (\%\ \mathrm{dietTL}_3 * \mathrm{TL3}_{conc}) + (\%\ \mathrm{dietTL}_4 * \mathrm{TL4}_{conc})$$

Where: $\%\ \mathrm{dietTL}_2$ = percent of TL2 fish in diet

$\%\ \mathrm{dietTL}_3$ = percent of TL3 fish in diet

$\%\ \mathrm{dietTL}_4$ = percent of TL4 fish in diet

Alternative 2 assumes that people consume fish at rates of: 3.8 g/day of TL2, 8.0 g/day of TL3, and 5.7 g/day of TL4, for a total rate of 17.5 g/day. Using Equation 1 and then Equation 2 to obtain safe fish tissue levels:

$$\frac{(0.10\ \mu g/kg\ day - 0.027\ \mu g/kg\ day) * 70\ kg}{17.5\ g/day\ all\ fish} = 0.29\ \mu g/g\ \text{MeHg, average in all fish (0.29 mg/kg}$$

Applying the TL4 and diet percentages and solving for TL2 concentration:

$$0.29\ mg/kg = (21.7\% * TL2_{conc}) + (45.7\% * TL2_{conc} * 4.5) + (32.6\% * TL2_{conc} * 4.5 * 2.9)$$

$$TL2_{conc} = 0.29/(0.21 + (0.45 \cdot 4.5) + (0.33 \cdot 4.5 \cdot 2.9)) = 0.04\ mg/kg$$

$$TL3_{conc} = 0.04\ mg/kg * 4.5 = 0.20\ mg/kg \text{ in large, TL3 fish}$$

$$TL4_{conc} = 0.04\ mg/kg * 4.5 * 2.9 = 0.58\ mg/kg \text{ in large, TL4 fish}$$

Alternative 4 assumes that people consume fish at rates of: 16 g/day each of TL3 and TL4, at a total rate of 32 g/day:

$$\frac{(0.10\ \mu g/kg\ day - 0.027\ \mu g/kg\ day) * 70\ kg}{32\ g/day\ TL4\ fish} = 0.16\ \mu g/g\ \text{MeHg in TL4 fish (0.16 mg/kg)}$$

$$0.16\ mg/kg = (50\% * TL3_{conc}) + (50\% * TL3_{conc} * 2.9)$$

$$TL3_{conc} = 0.082\ mg/kg \text{ in large, TL3 fish}$$

$$TL4_{conc} = 0.082\ mg/kg * 2.9 = 0.24\ mg/kg \text{ in large, TL4 fish}$$

Calculation of Objective for Small TL2 and TL3 Fish

Alternatives 3 and 4 contain an objective for small trophic level 2 and 3 fish that was developed using Equation 2 and the reference dose, body weight and consumption rate for California least tern, a federally-listed species. Wildlife species are assumed to receive all of their methylmercury from the local environment, hence the “intake from other sources” is zero.

Equation 1 Variables:

RfD	=	Reference dose for avian wildlife, representing the safe, total daily intake of methylmercury (21 micrograms MeHg/kg body weight per day).
Body weight	=	Average, female least tern body weight (0.045 kg)
Local fish consumption rate	=	Total ingestion rate of fish less than 50 mm in length from trophic levels 2 and/or 3 (31 g/day)

$$\frac{21\ \mu g/kg\ day * 0.045\ kg}{31\ g/day\ TL\ 2\ \&\ 3\ fish} = 0.03\ \mu g/g \text{ MeHg in small, TL2 and 3 fish } (0.03\ mg/kg)$$

APPENDIX C
COST CONSIDERATION CALCULATIONS FOR THE PROPOSED IMPLEMENTATION PROGRAM

TABLE OF CONTENTS

A. BACKGROUND & COMMON COST ASSUMPTIONS

The Central Valley Water Board proposes to amend the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins. The Delta is on the Clean Water Act Section 303(d) List of Impaired Water Bodies because of elevated levels of mercury in Delta fish. The goal of the proposed Basin Plan amendments is to lower fish mercury levels in the Delta so that the beneficial uses of fishing and wildlife habitat are attained. The proposed amendments include the:

- Addition of the commercial and sport fishing (COMM) beneficial use for the Delta;
- Establishment of numeric fish tissue objectives for methylmercury in Delta fish, and documentation of the assimilative capacity of ambient methylmercury in Delta waters based on those objectives;
- Adoption of methylmercury load and waste load allocations and total mercury limits;
- Adoption of an implementation strategy to (a) reduce methyl and total mercury loading to the Delta to enable compliance with the proposed fish tissue objectives for the Delta and the total mercury allocation assigned to the Delta by the San Francisco Bay mercury TMDL program, and (b) reduce methylmercury exposure to the fish-eating public;
- Adoption of a schedule for evaluating the progress of the implementation program, and making changes as needed using an adaptive management approach; and
- Addition of a monitoring and surveillance program.

To document the current use of the Delta as a fishery, staff proposes to include the COMM beneficial use designation for the Delta in the Basin Plan. The inclusion is not expected to incur any short- or long-term implementation costs. However, implementation of methyl and total mercury control actions to achieve the proposed fish tissue objectives, expansion of existing public education and outreach programs to reduce methylmercury exposure to the fish eating public and performance of surveillance and monitoring activities all would incur costs.

This appendix reviews a range of potential costs that may be associated with reasonably foreseeable methods of compliance with the implementation strategy adopted by the Central Valley Water Board for achieving the proposed fish tissue objectives and reducing the risk of methylmercury exposure to the fish eating public. The Central Valley Water Board does not specify the actual means of compliance by which responsible entities (e.g., dischargers, agencies or other persons responsible for total mercury and/or methylmercury sources) choose to comply with the proposed Basin Plan amendments. Therefore, to estimate the potential overall cost of implementing the proposed Basin Plan amendments, assumptions were made regarding the overall number and types of actions that may be implemented to comply with amendment requirements. Table 4.4 in Chapter 4 summarizes those costs, and the following sections provide explanations of how the costs were estimated along with critical assumptions.

All costs are presented in 2007 dollars. All costs that were referenced from other years were converted to 2007 dollars using the U.S. Department of Labor's Bureau of Labor Statistics Consumer Price Index Inflation Calculator (USDL, 2007). The cost evaluations rely on many common assumptions regarding sampling labor expenses and analytical costs. Table C.1 summarizes several of the common assumptions incorporated in cost evaluations for characterization and control studies and monitoring and surveillance activities. Additional assumptions and cost calculations are presented by source/discharger type in the following sections.

Some actions taken to comply with the proposed Basin Plan amendments could occur early during Phase 1 (e.g., a methylmercury characterization/control study) or later in Phase 2 (e.g., implementation of methylmercury management practices). Some actions could occur once (e.g., construction of a particular total mercury control project), while others may take place every year (e.g., ongoing discharge/receiving water monitoring, and operations/maintenance activities associated with methyl and total mercury control projects). Table 4.4 shows the overall cost of the proposed Phase 1 characterization and control studies. To develop standardized annual costs for other types of action – monitoring, risk management, and implementation and maintenance of methyl and total mercury control projects – staff assumed a project life of 30 years.

Since the implementation program does not require dischargers to conduct offset projects, the costs summarized in Table 4.4 do not include costs associated with methyl or total mercury offset projects. The overall cost of implementing the proposed Basin Plan amendments potentially could be substantially reduced if methyl and total mercury control actions could focus more on those sources that are more cost-effective to control while still achieving safe fish mercury levels throughout the Delta.

Table C.1: Assumptions Used for Estimating Costs for Sampling, Chemical Analysis, Study Design and Report Writing

Labor and Shipping Costs		
Study Component	**Assumed Value**	
Sampling labor for a 2-person sampling team	$140/hr	
Sampling duration per sampling location [(a)]	1 hour	
Study design, data analysis, and report writing labor	$100/hr	
Shipping costs per sampling event [(b)]	$90	
Chemical Analysis Costs [(c), (d)]		
Water Samples	**Method**	**Cost / Sample**
Methylmercury, Total (MeHg)	EPA 1630	$166
Dissolved Methylmercury, with Filtration	EPA 1630	$221
Mercury, Total (TotHg)	EPA 1631	$123
Dissolved Mercury, with Filtration	EPA 1631	$178
Suspended Sediment Concentration (SSC)	SM 2540B M	$25
Total Dissolved Solids	EPA 160.1	$30
Total Sulfate	EPA 300.0	$30
Total Sulfide	EPA 376.2	$42
Dissolved Sulfide	EPA 376.2	$42
Dissolved Organic Carbon	EPA 415.1	$88
Total Organic Carbon	EPA 415.1	$56
Chloride	EPA 300.0	$25
Inductively Coupled Plasma analysis (ICP)		$100
Sediment Samples	**Method**	**Cost / Sample**
Methylmercury	EPA 1630 mod	$202
Total Mercury	EPA 7473	$129
Sulfite / Sulfate Concentration	EPA 377.1 / EPA 300.0	$25
Moisture Content & Density	ASTM 2937	$22

(a) Sampling a new location for NPDES-permitted facility and MS4 monitoring programs is estimated to take a 2-person team an average of an additional hour to complete one or all constituents. This duration includes travel time. Sampling labor costs for new NPDES monitoring locations are calculated as: # of locations x 1 hour x $140/hr. Other monitoring programs (e.g., wetland and open-water studies) may require more time to access sites; study-specific assumptions are noted as applicable.

(b) It costs approximately $90 for a cooler that weighs 20 pounds, has the dimensions of 20 x 15 x 12 inches and is sent through priority overnight from Rancho Cordova to Washington State. Staff assumed that approximately 20 water samples could be transported in a cooler with this size and weight.

(c) This is a list of all analyses considered for all of the various study and monitoring designs. Not all of these analyses were included in each source type study or monitoring.

(d) Analytical laboratories bill their clients for QA/QC analyses (e.g., Matrix Spikes and Duplicates, Standard Reference Material, and Laboratory Duplicates) for smaller batches (e.g., less than 15 samples). However, analytical laboratories often analyze batches from different projects at the same time, in which QA samples are included in the cost. In addition, field duplicates, travel blanks, and samples splits between laboratories are common and necessary components of quality assurance project plans. Staff assumed that in general, analysis costs would include an additional 20% for field and laboratory QA samples.

B. CACHE CREEK SETTLING BASIN

The Cache Creek Settling Basin (basin) is a 3,600-acre structure located at the base of the Cache Creek watershed just west of the Sacramento Airport. The basin was constructed in 1937 to contain sediment that would otherwise build up in the Yolo Bypass and decrease its ability to protect the Sacramento region from flooding. The basin was modified in 1993 to increase its sediment trapping efficiency. It currently traps about 52% of the sediment volume input from the watershed. This equates to a trapping efficiency of about 64% of the sediment and total mercury mass loads (when the volumes of sand, uncompacted silt and clay are converted to sediment mass; see CDM, 2004b, Table 4-3).

The basin has a USACE-designed project life of 50 years with an average sediment volume trapping efficiency of about 50% over the entire project life (CDM, 2004a; USACE, 2005). The sediment trapping efficiency of the basin will decrease as it fills. The basin will fill to its design capacity in about 35 years, and its trapping efficiency may reach zero in about 50 years, unless a long-term maintenance program is established. At this time, the only maintenance program in effect for the basin is for the purpose of flood control upstream of the basin. USACE's draft sediment management plan includes the following activities to maintain the current 50% trapping efficiency over the 50-year life of the basin: construction and maintenance of a training channel and levee; incremental removal of the existing training levee; and raising the outlet weir in year 25 (~2018) (CDM, 2004b). Although the USACE's draft sediment management plan for the basin has not been finalized, DWR has done some maintenance activities in the settling basin including vegetation clearing, levee maintenance, and minor sediment removal projects. The basin is expected to be filled to design capacity at the end of the project life (50 years) in approximately 2042 (CDM, 2004a and 2004b). No program is in effect for the purpose of maintaining the trapping efficiency or extending the life of the basin beyond the USACE-designed project life of 50 years (USACE, 2005; Bencomo and Marchand, 2006).

Even though the basin currently traps about half the mercury that comes into it, the Cache Creek watershed still accounts for about 60% of all the inorganic mercury that enters the Yolo Bypass and is the largest single source of mercury-contaminated sediment to the Delta. In addition, under certain flow conditions the basin acts as a net source of methylmercury to the Yolo Bypass and Delta. As a result, the recommended Delta methylmercury TMDL implementation plan includes three sets of actions for the Cache Creek Settling Basin:

1. Develop and implement a basin maintenance and total mercury reduction program;
2. Conduct a methylmercury characterization and control study; and
3. Implement methylmercury management practices during Phase 2 of the Delta Methylmercury TMDL implementation program.

1. Basin Maintenance & Total Mercury Reduction Program

The proposed Basin Plan amendments require improvements to the basin to increase its trapping efficiency of mercury loads to 75%, which would require a sediment volume trapping efficiency of about 63%. Initial modeling results (CDM, 2004b) indicate that increasing basin trapping efficiency from 52% to 63% in terms of sediment volume would increase the total mercury mass load trapping efficiency from 64% to about 75%. Reasonably foreseeable methods to accomplish a sediment volume trapping efficiency of 63% are: (1) raising the outlet weir early (e.g., in 2015 instead of 2018), (2) excavating the basin (e.g., periodically removing sediment that has accumulated in the basin), (3) enlarging the basin, or (4) a combination of excavating and raising the weir early, or enlarging the basin and raising the weir early. CDM's modeling results indicated that the combination of excavating the basin and raising the weir early produced the largest increase in trapped sediment volume and mercury mass.

Costs of increasing the mercury mass trapping efficiency costs could range from about \$590,000/yr to \$2.1 million/yr (averaged over 30 years), based on the following assumptions:

- Raising the basin's outlet weir in 2018 and excavation to maintain the USACE-design's 50% sediment trapping efficiency (by volume) is considered baseline;
- Reasonable methods that produce a low cost estimate for increasing sediment and mercury trapping efficiency are raising the outlet weir early, enlarging the basin (a one-time cost), and sediment excavation; and
- Reasonable methods that produce a high cost estimate are raising the outlet weir early and excavating more sediment per year[1] than the low-cost estimate.

The following text and Table C.2 detail the calculations for annual cost estimates.

Staff assumed that although the original USACE-design life of the basin was 50 years, the basin will need to function for much longer (i.e., indefinitely) to prevent sedimentation of the Yolo Bypass. Annual cost estimates for removing sediment on an indefinite basis are provided in Table C.3.

Raising the outlet weir to final specifications described in the current sediment management plan would involve adding six feet of concrete to the existing structure; other levee improvements are not expected to be needed, as they are already at design elevations. Increasing the size of the basin would require easements for adjacent land and construction of new levees. Periodic sediment removal would require excavation equipment and trucks to transport the excavated material outside the basin. Because the sediment likely does not contain hazardous concentrations of mercury, the sediment could be used for building materials, landfill cover, or other construction projects. Erosion control measures to minimize transport of excavated material into surface waters are already required in order to comply with existing Basin Plan sediment and turbidity objectives. The environmental affects of these construction and maintenance activities are described in Chapter 7 (CEQA Environmental Checklist and Discussion).

The basin has an average sediment trapping efficiency of about 50% (by volume) over its entire 50-year design life, assuming the weir is raised in about Year 25 (Figure C.1). After Year 50 (~2042), the basin's trapping efficiency is expected to drop below 40%, and may reach zero by

1 The average trapping efficiency of the CCSB is expected to decrease as the basin fills with sediment due to the loss of sedimentation storage space (CDM, 2004b). Therefore, trapping efficiency is proportional to the available storage space in the basin. Expanding the basin in addition to raising the weir will increase the available storage space more than raising the weir alone. Thus, raising the weir alone would require more excavation to increase the available storage space to a large enough volume to maintain an average trapping efficiency of 63%.

about Year 63 (~2055). Although there is no plan in place for maintaining the basin for more than 50 years, staff assumed that maintaining the basin at a 50% trapping efficiency was a baseline condition because this is necessary to maintain the capacity of the Yolo Bypass and ultimately provide continued flood protection for the greater Sacramento region. To maintain a basin trapping efficiency of about 50%, excavation of about 500,000 yd^3/yr would need to begin in about 2040 (Louie and Wood, 2007).

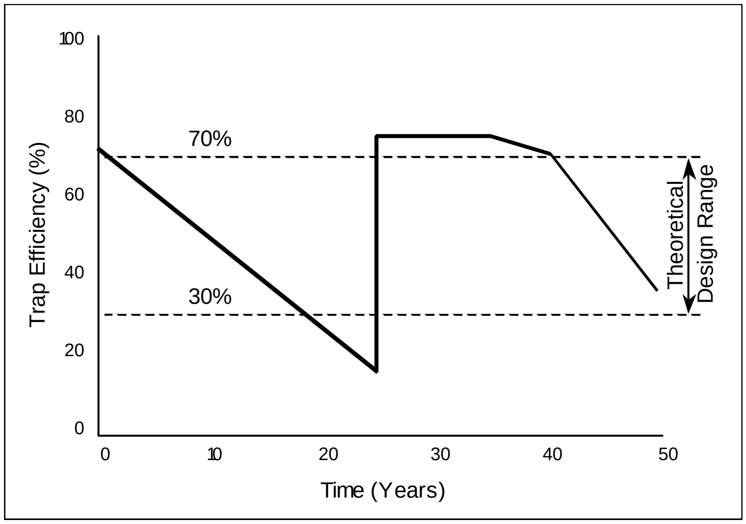


Figure C.1: Cache Creek Settling Basin Trapping Efficiency During the 50-Year Project Life Predicted by USACE Modeling (CDM, 2004a)

The proposed Basin Plan amendments would require improvements to the basin's mercury/sediment trapping efficiency prior to 2018, which would likely entail raising the weir earlier than planned by the USACE (e.g., in 2015). The total cost to raise the weir ranges from $2.8 million (LWA, 2005) to $6.0 million (CDM, 2007). Because this activity was already planned, it is considered a baseline condition. However, there may be some cost associated with raising the weir earlier than planned. As noted in Chapter 7 (Discussion Section VIII. Hydrology and Water Quality), "*future training channel bed aggradation due to sedimentation could significantly reduce flow capacity upstream of the CCSB unless aggressive sediment and vegetation maintenance is conducted*" (CDM, 2004a, page 37). Therefore, raising the weir earlier than planned could increase the number of years of exposure to increased flood risk by about three years.

This potential increase in flood risk exposure could be mitigated by increased excavation in the basin to maintain its flood carrying capacity during the initial three years of the project. CDM (2004b) modeling estimated thalweg elevations within the training channel increases 1 to 7 feet in 15 years. As a result, additional excavation of the training channel by about 1 ft could offset the potential increase in flood risk from raising weir three years early. Excavating the training channel, which is about 14,000 feet long and 30 feet wide, by 1 ft would require the removal of about 15,560 yd^3 of sediment. Assuming a cost of \$6/yd^3 to \$12/yd^3 (see Table C.3 footnote [b]), the additional excavation costs could range between about $93,000 and $187,000 ($3,100/yr to $6,200/yr when averaged over 30 years).

Improving the basin's efficiency also would likely entail periodic excavation to increase the sediment volume trapping efficiency to 63% and to extend the life of the basin. The CDM (2004b) modeling estimated that 100,000 cubic yards of sediment/yr would need to be excavated in conjunction with raising the weir to maintain trapping efficiency at 63% for the rest of the 50-year project life of the basin. However, even more maintenance-related excavation likely would be necessary to maintain the trapping efficiency at 63% indefinitely.

Enlarging the basin to help improve its efficiency would require removal and construction of levees and acquisition of property easements to allow periodic flooding. Modeling by CDM indicated that expanding the basin in conjunction with raising the weir early would increase the sediment trapping efficiency to 61% (by volume) for the rest of the 50-year project life of the basin (CDM, 2004b). CDM (2007) estimated the cost of enlarging the basin 1,500 acres to be about $14.7 million, which includes costs for removal of existing levees and construction of new levees, but not for new easements. The State currently has easements in the basin for operations and maintenance of the basin that cost $1,420/acre in 1995 (Final Order of Condemnation, 14 July 1995), and would cost about $1,940/acre when adjusted for inflation. New easements for 1,500 acres could cost about $2.9 million in 2007 dollars. The combined cost of construction and easements would cost about $17.6 million or $587,000/yr over a 30-year period.

Table C.2 shows the range in potential costs with increasing and maintaining the basin trapping efficiency at 63% (by volume), standardized over a 30-year period. Potential costs range from about $590,000/yr to $2.1 million/yr above costs to maintain the existing trapping efficiency. Any additional improvements to the basin – other than weir improvement, sediment excavation, and basin expansion – may be evaluated by the proposed characterization and control studies described in the following section.

Table C.3 shows the estimated costs of sediment excavation under different improvement scenarios. All of the evaluated improvement scenarios could have long-term costs, which would occur after each scenario's 30-year project life, of about $780,000/yr to $1.6 million/yr above baseline costs to maintain a 63% trapping efficiency indefinitely.

Table C.2: Potential Range of Costs to Maintain and Increase Cache Creek Settling Basin Trapping Efficiency

Scenario	Excavation Strategy [(a)]	Total Excavation Amount over 30 Years [(a)] (yd^3)	Annual Excavation Amount over 30 years (yd^3/yr)	Annual Excavation Amount in Addition to Baseline Excavation (yd^3/yr)	Cost of Sediment Removal and Disposal ($/$yd^3$)	Annual Excavation Cost ($/yr)	Cost to Raise Weir Early [(b)] ($/yr)	Cost to Expand Basin ($/yr)	Total Cost Above Baseline (Rounded) ($/yr)
Baseline (raise weir in 2018 & maintain 50% trapping efficiency indefinitely)	Begin excavating 500,000 yd^3/yr in 2040.	3,000,000	100,000		$6 - $12	$600,000 - $1,200,000	–	–	–
Raise weir in 2015 & maintain 63% trapping efficiency indefinitely	Begin excavating 630,000 yd^3/yr in 2033	8,190,000	273,000	173,000	$6 - $12	$1,038,000 - $2,076,000	$3,111- $6,222		$1,000,000 - $2,100,000
Raise weir and expand basin in 2015 & maintain 63% trapping efficiency indefinitely	Begin excavating 20,000 yd^3/yr in 2016. Increase to 630,000 yd^3/yr in 2044	1,820,000	60,667	0	$6 - $12	$0	$3,111- $6,222	$587,000	$590,000

(a) Based on the USACE design trapping efficiency rates over time (Figure C.1) and initial modeling and cost estimates by CDM (CDM, 2004b & 2007), staff estimated how much excavation would need to take place to maintain trapping efficiencies of 50% and 63% indefinitely and potential costs over a 30-year period (Louie and Wood, 2007). The proposed Basin Plan amendments require the entities responsible for maintaining the Cache Creek Settling Basin to initiate control actions to reduce total mercury loads from the Cache Creek Settling Basin by five years after the effective date of the amendments, and complete project improvements by seven years after the effective date of the amendments. For the purpose of estimating costs, staff assumed that the weir improvements, basin enlargement and/or any other improvements would be completed in 2016, and that the 30-year cost estimate period would encompass 2016 to 2045. However, maintenance excavation would need to continue indefinitely after 2045 under both the baseline and improvement scenarios.

(b) Costs do not include baseline costs associated with raising the weir.

Table C.3: Potential Costs of Sediment Excavation in the Cache Creek Settling Basin

Excavation Options	Sediment Removed (yd^3/yr)	Cost of Sediment Removal & Disposal (\$/yd^3)	Annual Cost (\$/yr)
Excavation (with raising weir) to maintain trapping efficiency to 50% for remainder of the USACE-designed 50-year basin life [a]	100,000	\$6 - \$12 [b]	\$600,000 - \$1,200,000
Excavation to maintain 50% trapping efficiency indefinitely [c]	500,000	\$6 - \$12	\$3.0 million - \$6.0 million
Excavation to maintain trapping efficiency at 63% indefinitely	630,000	\$6 - \$12	\$3.78 million to \$7.56 million (\$780,000 to \$1.56 million above baseline costs to maintain 50% trapping efficiency)

(a) Periodic removal of sediment (500,000 yd^3 every 5 years), in conjunction with raising the weir early, would increase the mercury-mass trapping efficiency of the basin to about 75% (CDM, 2004b, Table 4-3). However, the excavation of 100,000 yd^3/yr would only minimally extend the life of basin, and the basin will become ineffective at trapping sediment in approximately 30 years after raising the weir; hence the need for continued maintenance excavation.

(b) It is expected that there will be a market for the removed sediment for use in building materials, landfill cover, and other construction projects. The \$6/yd^3 estimate assumes that there would be a market for 50% of the sediment removed.

(c) The trapping efficiency of the basin was estimated to vary from 20 to 70% for an average of 50% over the life of the USACE's 50-year project (CDM, 2004a). The basin currently traps about 50% of the approximately 1 million cubic yards of sediment that enters it (CDM, 2004b, Table 4.1). Once the weir is raised, removing about 500,000 yd^3/yr could extend the life of the basin indefinitely.

2. Phase 1 Methylmercury Characterization & Control Study

The Cache Creek Settling Basin appears to be a source of methylmercury at low flows and a sink of methylmercury at high flows (>4,000 cfs) (Foe *et al*., 2006). Accordingly, the methylmercury characterization and control study should evaluate both low and high flow conditions and conditions in the low flow channel. In their Cache Creek Settling Basin Mercury Study, CDM (2004a) identified the data needed to better characterize total mercury conditions in the basin. The methylmercury characterization study should address both methylmercury and total mercury data needs. The characterization study could have several components, including but not limited to, the following:

1. Evaluation of methyl and total mercury concentrations and loading during low and high flow conditions;
2. Evaluation of total mercury concentrations in surface and subsurface sediments in the low flow channel and throughout the basin to characterize depositional patterns over time;
3. Evaluation of total mercury and methylmercury concentrations in surface sediments in the low flow channel and throughout the basin to determine areas or conditions that favor methylation within the basin during different levels of inundation.

A characterization study that has one or all or these components could cost from about \$60,000 to \$180,000. Table C.4 describes the assumptions used to develop this cost estimate. As noted earlier, the Central Valley Water Board does not specify the method of compliance. The assumptions in Table C.4 are made only to estimate reasonably foreseeable costs.

A control study could have several components, including but not limited to, the following:

1. Monitoring to evaluate total mercury and methylmercury loading from the Cache Creek Settling Basin after baseline activities such as low-flow channel maintenance dredging and raising the weir take place and after excavation takes place to increase the basin's sediment trapping efficiency. This monitoring data, combined with the data collected by the characterization study, could determine whether changes in inundation patterns or exposure of sediment with higher mercury levels resulting from excavation and raising the weir cause an increase or decrease in mercury methylation within the basin.
2. If sediment excavation or raising the weir caused mercury methylation to increase within the basin, additional surface sediment monitoring could take place to determine where and when the methylation occurs. The results of this monitoring effort could be used to guide future excavation efforts such that they result in topographies with inundation patterns or durations that cause less methylation.
3. Modifying the outlet structure to increase outflow discharge so that the residence time in the basin is decreased during relatively low-flow conditions. This could be achieved by constructing a manually operated gate to allow for more control of water releases. The gate could be used to increase residence time during high flows (>4,000 cfs) and decrease residence time during low flows or when conditions favor methylation. A control study could evaluate the conditions or flow that allow for the best trapping efficiency of sediment and total mercury while limiting methylation. The manual gate could be a part of the design and construction of the newly raised weir and is expected to generate little or no additional cost.

A control study that has one or all or these components could cost from about $60,000 to $150,000. Table C.5 describes the assumptions used to develop this cost estimate. As with Table C.4, the study assumptions in Table C.5 are made only to estimate reasonably foreseeable costs and do not define or limit study elements that responsible parties may evaluate. Additional methylmercury control options that involve improvements to the Cache Creek Settling Basin structure or operation may be evaluated by the characterization and control studies.

Table C.4: Potential Components & Costs of a Cache Creek Settling Basin Methylmercury Characterization Study

Total Mercury and Methylmercury Loading Study					
	Analysis Cost per Sample [(a)]	# of Sampling Events [(b)]	# of Sampling Locations [(c)]	Shipping Cost for One Sampling Event	Costs
Aqueous TotHg, MeHg & SSC Analyses:	$377	20	2	$45	$15,980
		Study Design:		80 hours x $100/hr	$8,000
		Field Labor: [(c)]		160 hours x $140/hr	$22,400
		Data Analysis & Report:		120 hours x $100/hr	$12,000
				TOTAL:	**$58,380**

Sediment Core Sampling to Characterize TotHg Depositional Patterns & Surface Sediment Sampling to Characterize Areas or Conditions that Favor Methylation					
1st Sampling Event	Sediment Analysis Cost [(a)]	# of Core Locations	Samples per Core	Shipping Cost	Costs
TotHg Analysis:	$155	20	2 (surface & 1 ft depth)	$30 [(d)]	$6,230
MeHg Analyses:	$242	20	1 (surface)	$45	$4,885
Subsequent Sampling Events	Sediment Analysis Cost [(a)]	# of Sampling Locations [(e)]	# of Sampling Events [(f)]	Shipping Cost for One Sampling Event	Costs
TotHg & MeHg Analyses:	$397	10	10 (surface)	$50 [(d)]	$40,200
	Study Design & Hydrologic Analysis:			200 hours x $100/hr	$20,000
	Field Labor – 1st Sampling Event: [(g)]			32 hours x $140/hr	$4,480
	Field Labor – Later Sampling Events: [(g)]			160 hours x $140/hr	$22,400
		Data Analysis & Report:		200 hours x $100/hr	$20,000
				TOTAL:	**$118,195**

Table C.4 Footnotes:

(a) Analysis costs include an additional 20% for field and laboratory QA samples.
(b) Assumes 20 sampling events during a range of flow conditions over a three-year period.
(c) Sampling locations would be at the basin inflows and outflows. Assumes that a two-person sampling team would sample both inflow and outflow sites in one 8-hour day at $140/hr.
(d) Shipping cost for samples for TotHg analysis based on parcel post rates because such samples do not require overnight shipping.
(e) Sampling of surface sediment could take place throughout the inundated portions of the basin during different inundation stages. Number of locations is expected to vary depending on inundation stage (e.g., between 5 and 15) and to average 10 locations per sampling event over the study period.
(f) Assumes 10 sampling events during a range of inundation stages over a three-year period.
(g) Assumes that a two-person sampling team would sample 10 sites in two 8-hour days at $140/hr.

Table C.5: Potential Components and Costs of a Cache Creek Settling Basin Methylmercury Control Study

Monitoring after (1) Baseline Low-Flow Channel Maintenance Dredging, (2) Raising Weir or (3) Other Excavation in the Basin to Increase Trapping Efficiency					
	Analysis Cost per Sample [(a)]	# of Sampling Events [(b)]	# of Sampling Locations [(b)]	Shipping Cost for One Sampling Event	Costs
Aqueous TotHg, MeHg, & SSC Analyses:	$377	20	2	$45	$15,980
	Study Design:			80 hours x $100/hr	$8,000
	Field Labor (Water Sampling): [(b)]			160 hours x $140/hr	$22,400
	Data Analysis & Report:			120 hours x $100/hr	$12,000
				TOTAL:	**$58,380**

Additional Surface Sediment Monitoring If Sediment Excavation or Raising the Weir Causes Mercury Methylation to Increase within the Basin					
	Analysis Cost per Sample [(a)]	# of Sampling Events [(c)]	# of Sampling Locations [(d)]	Shipping Cost for One Sampling Event	Costs
Sediment TotHg & MeHg Analyses: [(d)]	$397	10	10	$50	$40,200
	Study Design:			80 hours x $100/hr	$8,000
	Field Labor - Sediment Sampling: [(d)]			160 hours x $140/hr	$22,400
	Data Analysis & Report:			200 hours x $100/hr	$20,000
				TOTAL:	**$90,600**

(a) Analysis costs include an additional 20% for field and laboratory QA samples.
(b) Calculations assume 20 sampling events over 3 years at 2 locations (basin inflows and outflows) and that a two-person sampling team would sample both sites in one 8 hour day at $140/hr.
(c) Calculations assume 10 surface sediment-sampling events during a range of inundation stages over a three-year period.
(d) Number of locations is expected to vary depending on inundation stage (e.g., between 5 and 15) and to average 10 locations per sampling event over the study period. Staff assumed that a two-person sampling team would sample all sites in two 8-hour days at $140/hr.

C. NPDES PERMITTED FACILITIES

1. Effluent & Receiving Water Monitoring for Methyl and Total Mercury

Tables C.20 through C.24 at the end of this appendix provide information about the NPDES-permitted facilities in the Delta and its tributary watersheds downstream of major dams (e.g., type of facility, treatment processes, whether a facility discharges to a 303(d)-Listed waterway, and current permit requirements for monitoring and pollution prevention). The proposed Basin Plan amendments require 21 NPDES permitted dischargers to monitor methyl and total mercury in their effluent and receiving waters, and 26 additional dischargers to monitor methylmercury in their effluent only. NPDES dischargers that discharge to surface waters are currently required to implement monitoring programs; however, effluent and/or receiving water monitoring for methyl and/or total mercury may be new parameters for their monitoring programs. The costs of the new monitoring required by the proposed Basin Plan amendments will vary among the dischargers depending on their current mercury monitoring. The additional monitoring for dischargers required by the proposed amendments ranges from no new monitoring to new monthly effluent and receiving water methyl and total mercury monitoring. Table C.6 lists the number of facilities that would be required to incorporate new methyl and total mercury monitoring. The costs associated with additional methyl and total mercury monitoring are presented in Table C.7. The estimated cost of additional monitoring for all facilities with new monitoring requirements is $172,000/yr. The cost includes sample collection and analyses, laboratory and field QA/QC, and assumes the monitoring results will be included with annual monitoring reports currently required by NPDES permits.

2. Phase 1 Methylmercury Characterization & Control Studies

The proposed Basin Plan amendments require 18 NPDES permitted WWTPs to conduct methyl and total mercury characterization and control studies (Table C.6). Each WWTP has the option to conduct either an individual study of its facility's treatment processes or a collaborative study with other WWTPs with similar treatment processes. Staff estimated that analytical expenses for previous fate and transport studies conducted by SRCSD and the San Jose/Santa Clara Water Pollution Control Plant (Palmer, 2005; SJ/SC, 2007) could have cost about $70,200 and $512,000, respectively, based on the information cited in their study reports (e.g., number of sample dates and waste stream and sludge samples collected and types of analyses performed) and the assumption that the laboratory analyses were conducted by contracted laboratories. The SJ/SC study likely cost much less than staff's estimate because many of its analyses were performed in-house.

Assuming the dischargers conduct a collaborative study, characterization and control study costs could range from about $500,000 to $1.3 million (Table C.8). Additional costs may occur if WWTPs elect to conduct pilot projects to evaluate different methylmercury management practices within their facility; it is possible that some of the costs to evaluate different management practices may be incorporated into the characterization studies.

Table C.6: NPDES Municipal and Industrial Facilities with New Requirements (above Baseline) per Implementation Alternative 3 for Methyl and Total Mercury Monitoring, Characterization and Control Studies, and Mercury Evaluation and Minimization Plans.

Agency	NPDES No.	Monitor MeHg in Receiving Water & Effluent [(a)]	Monitor MeHg in Effluent [(a)]	Participate in MeHg Characterization & Control Studies	Implement TotHg Evaluation & Minimization Plan	New Sampling Required [(a)]
Anderson WWTP	CA0077704		M	X	X	EFF MeHg
Atwater WWTP	CA0079197		M		X	EFF MeHg
Auburn WWTP	CA0077712		M		X	EFF MeHg
Brentwood WWTP	CA0082660	M			[(b)]	RW TotHg & MeHg, EFF MeHg
California, State of, Central Heating/ Cooling Facility [(c)]	CA0078581	Q			[(c)]	EFF & RW TotHg & MeHg
Chico Regional WWTP	CA0079081		M	X	X	EFF MeHg
Corning Industries/ Domestic WWTP	CA0004995		M		X	EFF MeHg
Davis (City of) WWTP	CA0079049	M		X	X	RW TotHg & MeHg, EFF MeHg
Deuel Vocational Institute WWTP	CA0078093	Q				EFF & RW TotHg & MeHg
Discovery Bay (City of) WWTP	CA0078590	M			X	EFF & RW TotHg & MeHg
El Dorado ID Deer Creek WWTP	CA0078662		M		X	EFF MeHg
El Dorado ID El Dorado Hills WWTP	CA0078671		M		[(b)]	EFF MeHg
Galt (City of) WWTP	CA0081434		M	X	X	EFF MeHg
GWF Power Systems	CA0082309	Q				RW TotHg & MeHg, EFF MeHg
Lincoln WWTP	CA0084476		M		[(b)]	EFF MeHg
Linda Co Water Dist WWTP	CA0079651		M		X	EFF MeHg
Live Oak WWTP	CA0079022		M	X	X	EFF MeHg
Lodi (City of) White Slough WWTP	CA0079243	M			[(b)]	RW TotHg & MeHg, EFF MeHg
Manteca (City of) WWTP	CA0081558	M		X	[(b)]	RW TotHg & MeHg, EFF MeHg
Merced WWTP	CA0079219		M	X	X	EFF MeHg
Mirant Delta LLC Contra Costa Power Plant	CA0004863	Q			X	EFF & RW TotHg & MeHg
Modesto (City of) WWTP	CA0079103		M	X	[(b)]	EFF MeHg
Mountain House CSD WWTP-1	CA0084271	M		X	[(b)]	No new monitoring required
Oakwood Lake Subdivision Mining Reclamation	CA0082783	Q				RW TotHg & MeHg, EFF MeHg
Olivehurst PUD WWTP	CA0077836		M	X	X	EFF MeHg

Table C.6: NPDES Municipal and Industrial Facilities with New Requirements (above Baseline) per Implementation Alternative 3 for Methyl and Total Mercury Monitoring, Characterization and Control Studies, and Mercury Evaluation and Minimization Plans.

Agency	NPDES No.	Monitor MeHg in Receiving Water & Effluent [a]	Monitor MeHg in Effluent [a]	Participate in MeHg Characterization & Control Studies	Implement TotHg Evaluation & Minimization Plan	New Sampling Required [a]
Oroville WWTP	CA0079235		M	X	X	EFF MeHg
Placer Co. SMD #1 WWTP	CA0079316		M	X	X	EFF MeHg
Proctor & Gamble Co. WWTP	CA0004316		M		X	EFF MeHg
Red Bluff WWRP	CA0078891		M		X	EFF MeHg
Redding Clear Creek WWTP	CA0079731		M		X	EFF MeHg
Redding Stillwater WWTP	CA0082589		M		X	EFF MeHg
Rio Vista Main WWTP	CA0079588	Q			(b)	RW TotHg & MeHg, EFF MeHg
Rio Vista Trilogy WWTP / Northwest WWTP	CA0083771	Q		X	X	RW TotHg & MeHg, EFF MeHg
Roseville Dry Creek WWTP	CA0079502		M		(b)	EFF MeHg
Roseville Pleasant Grove WWTP	CA0084573		M		(b)	EFF MeHg
Sacramento Combined WWTP	CA0079111	Q		X	X	EFF & RW TotHg & MeHg
San Joaquin Co DPW - Flag City WWTP	CA0082848	Q				RW TotHg & MeHg, EFF MeHg
SRCSD Sacramento River WWTP	CA0077682	M		X	(b)	RW TotHg & MeHg, EFF MeHg
SRCSD Walnut Grove WWTP (CSD1)	CA0078794	Q				RW TotHg & MeHg, EFF MeHg
Stockton (City of) WWTP	CA0079138	M		X	(b)	RW TotHg & MeHg, EFF MeHg
Tracy (City of) WWTP	CA0079154	M		X	(b)	RW TotHg & MeHg
Turlock (City of) WWTP	CA0078948		M		(b)	EFF MeHg
UC Davis WWTP	CA0077895		M		X	EFF MeHg
Vacaville Easterly WWTP	CA0077691		M		(b)	EFF MeHg
West Sacramento WWTP	CA0079171	M			X	RW TotHg & MeHg, EFF MeHg
Woodland WWTP	CA0077950	M			X	RW TotHg & MeHg, EFF MeHg
Yuba City WWTP	CA0079260		M	X	X	EFF MeHg

(a) M: monthly monitoring, Q: quarterly monitoring, RW: receiving water, EFF: effluent.
(b) Facilities already required by their NPDES permits to implement some type of mercury minimization program (e.g., pollution prevention plans for mercury defined by Section 13263.3 of the California Water Code or other mercury reduction efforts).
(c) The State of California Central Heating/ Cooling Facility's NPDES permit indicates that it does not add any chemicals to its cooling water or other waste to its discharge. Therefore, staff recommends that it not be required to implement a total mercury minimization program.

Table C.7: Additional Costs Associated with New Monitoring Requirements for NPDES Facilities.

Component	New Sampling Requirement Scenarios [a]			
	EFF & RW TotHg & MeHg	EFF MeHg, RW TotHg & MeHg	RW TotHg & MeHg	EFF MeHg
Analysis Cost per Sample	$578	$455	$289	$166
Sampling Labor ($140/hr for a 2 person team)	$50	$35	$35	$25
Shipping Cost per Sampling Event	$90		$45	
Total Cost per Sampling Event	$718	$490	$369	$191
Annual Cost for Monthly Sampling	$8,616	$5,880	$4,428	$2,292
Annual Cost for Quarterly Sampling	$2,872	$1,960	$1,476	$764
Annual Cost for Monthly Sampling Including 20% for QA/QC	$10,339	$7,056	$5,314	$2,750
Annual Cost for Quarterly Sampling Including 20% for QA/QC	$3,446	$2,352	$1,771	$917

(a) Depending on existing, facility-specific NPDES permit monitoring requirements, new monitoring requirements resulting from the proposed Basin Plan amendments could range from simply adding methylmercury analyses for effluent (EFF) to adding methylmercury and total mercury analyses for both effluent and receiving water (RW). Potential new monitoring requirements under Implementation Alternatives 2 and 3 for each NPDES facility are presented in Tables C.6 and C.23.

3. Methylmercury Concentration Limits

The proposed facility-specific methyl mercury concentration limits for existing facilities are based on data derived from conditions that represent normal operational conditions. The limits would not require the facilities to implement any new processes as long as the facilities maintain the efficiency of existing treatment processes and pretreatment programs. Because the exceedance of the concentration limits would represent a material change in treatment or pretreatment conditions, the identification of possible sources of the change or the submission of a control strategy would not be a new requirement. However, the cost to sample and analyze methylmercury in addition to current parameters would be new. The estimated cost of new accelerated methyl mercury monitoring is $7,600 per exceedance. The number of exceedances that could occur at different facilities is not known. Hence, potential costs associated with maintaining methylmercury concentration limits are not included in Table 4.4.

4. Total Mercury Evaluation and Minimization Programs

The proposed Basin Plan amendments require new and existing municipal WWTPs, power plants, and heating/cooling facilities that discharge greater than 1 mgd to the Delta, Yolo Bypass, or tributary watersheds downstream of major dams to monitor total mercury in their effluent, implement evaluation and minimization programs for total mercury discharges, and maintain compliance with a USEPA-approved pretreatment program, as applicable. Total mercury monitoring cost estimates are described above in Section C.1. Compliance with a USEPA approved pretreatment program by industrial WWTPs is required with or without the proposed Basin Plan amendments; therefore, there are no new costs associated with its compliance. For facilities currently implementing pollution prevention plans in accordance with

CWC §13263.3 or pollution minimization plans for total mercury, the costs to maintain compliance with the proposed Basin Plan amendment requirements are estimated to be zero or negligible. Conversely, facilities that have not yet implemented mercury-specific control measures could incur new costs.

Reasonably foreseeable methods of compliance with evaluation and minimization requirements could include, but are not restricted to, the following:

- Submit a mercury evaluation and minimization plan to the Central Valley Water Board. Staff recommends that the mercury evaluation plans include the following elements:
  - A description of the discharger's existing mercury control efforts and baseline annual average effluent total mercury concentration and loads;
  - A description of all mercury sources contributing, or potentially contributing, to the mercury loading in the facility influent;
  - An analysis of potential pollution prevention and control actions that could reduce effluent total mercury concentrations and/or loads;
  - A description of the tasks, cost, and time required to implement actions to control effluent total mercury concentration and load;
  - A monitoring program for determining the results of the pollution prevention and control actions; and
  - An analysis of the benefits and any potential adverse environmental impacts, including cross-media impacts or substitute chemicals, that may result from the implementation of the mercury minimization plan.
- Implement mercury-specific control actions.
- Report annually to the Board all mercury monitoring results, a summary of all actions undertaken during the previous year pursuant to the minimization plan, an evaluation of those actions; and a description of actions to be taken in the following year.

Existing NPDES permits require 15 of 40 municipal WWTPs that discharge greater than 1 mgd in the Delta and its tributary watersheds downstream of major dams to implement total mercury pollution prevention plans in accordance with CWC §13263.3 or other similar mercury minimization programs. Hence, the proposed amendments' requirement for mercury discharge evaluation and minimization is a new requirement for only 25 WWTPs and one power plant[2]. The potential new costs, as a total for all facilities, would be about $3.6 million/yr to $7.3 million/yr (averaged over 30 years), based on the following:

- The cost to develop and submit a mercury evaluation and minimization plan to the Board would be about $416,000 [160 hours/facility x $100/hour x 26 facilities]. Averaged over 30 years, this would be about $14,000/yr.
- The cost for municipal WWTPs to implement mercury minimization actions would range from about $3.5 to $7.2 million/yr. Depending on the service area, implementing a pollution prevention program ranges between $290,000 and $400,000/year/facility (LWA,

[2] The State of California Central Heating/ Cooling Facility's NPDES permit (CA0078581) indicates that it does not add any chemicals to its cooling water or other waste to its discharge. Therefore, even though it discharges greater than 1 mgd, staff recommends that it not be required to implement a total mercury minimization program.

2002). Facilities servicing small communities or within close proximity to another facility possibly could implement shared pollution prevention programs to reduce costs. The potential implementation costs assume that between 12 and 18 individual or coordinated programs would be implemented, and that the programs incorporate monitoring to evaluate their effectiveness.

- The cost for a power plant to identify sources of mercury in its waste streams and modify procedures or materials to reduce the mercury in its discharge would be about $8,000/yr to $23,000/yr. The facility could be required to characterize its current waste streams and discharges. For the first year of monitoring, it could cost about $14,000 to conduct six sampling events (four quarterly and two storm events) at five monitoring locations and to analyze the samples for methylmercury, total mercury and SSC ($377/sample (including 20% for QA/QC) plus field labor). Monitoring during following years could be limited to two monitoring locations sampled four times a year ($4,000/year). Averaged over 30 years, monitoring would cost about $4,300/year. Costs for pollution prevention measures to reduce total mercury discharges[3] could cost about $5,000 to $20,000/yr, depending on the sources of mercury to the waste stream and chemicals used at the complex (see Tables.G.6 and G.7 in Appendix G of the TMDL Report).
- The cost to report the effectiveness evaluation of control actions taken during the past year and a description of actions planned for the next year to the Board would be about $52,000/yr to $76,000/yr [40 hours x $100/hour x (13 to 19 reports)].

Staff assumed that mercury minimization requirements based on best practicable treatment and control would be baseline requirements in NPDES permits for new facilities that begin discharging after the effective date of the proposed amendments.

[3] Pollution prevention measures to reduce total mercury discharges could include identifying and labeling instruments and chemicals that contain mercury; implementing effective maintenance, disposal, recycling, and spill response plans; finding alternative instruments and chemicals that do not contain mercury; and switching to low-mercury chemicals (e.g. caustic soda and sulfuric acid with lower mercury levels).

Table C.8: Potential Costs for NPDES WWTP Characterization and Control Studies.

	Low	High
STUDY DESIGN		
Assumed hourly rate	$100	
# of hours to conduct literature review, survey ongoing projects, and write report to prepare for study design meetings	60	
# of hours to review 13267 monitoring data and contact all facilities sampled to determine the exact treatment processes that took place when the samples were collected	120	
# of WWTPs to be sampled during C&C Study	5	7
# of hours to develop preliminary and final study plan reports study design, assuming 60 hours per WWTP sampled	300	420
Study Design Subtotal:	**$48,000**	**$60,000**
FIELD LABOR		
Cost per day for 2-person sampling team charging $140/hr for 8 hours	$1,120	
# of WWTPs to be sampled during C&C Study [(a)]	5	7
# of sampling events over one year	12	18
# of Field Days (assumes one WWTP is sampled per 8-hour day)	60	126
Field Labor Subtotal:	**$67,200**	**$141,120**
SAMPLE ANALYSIS		
Cost per sampling event + 20% field & laboratory QA/QC [(b)]	$1,008	
# of WWTPs to be sampled during C&C Study	5	7
# of sampling events over one year	12	18
# of sampling locations in waste stream	5	8
Sample Analysis Subtotal:	**$302,400**	**$1,016,064**
DATA ANALYSIS & REPORT WRITING (Assumed for Collaborative Characterization & Control Study)		
Assumed hourly rate.	$100	
# of WWTPs to be sampled during C&C Study	5	7
# of hours to evaluate data (summaries, plots, graphs, and other statistical analyses) on an ongoing basis in order to adjust sampling plan as needed when specific questions arise, assuming 20 hours per WWTP evaluated.	100	140
# of hours to write progress report, assuming 20 hours per WWTP evaluated.	100	140
# of hours for data analysis and draft and final reports, assuming 60 hours per WWTP evaluated.	300	420
Data Analysis & Report Writing Subtotal:	**$50,000**	**$70,000**
Potential Range of Costs for Characterization and Control Study:	**$467,600**	**$1,287,184**

(a) Assumes that WWTPs participate in one collaborative study. There are about five to seven general suites of treatment practices utilized by WWTPs in the Delta region.
(b) Assumes that external laboratories conducted analyses for filtered and unfiltered MeHg and TotHg, SSC, TDS, total sulfate, total sulfide, and chloride (see Table C.1) and that there was no cost to measure dissolved oxygen and pH.

5. Phase 2 Implementation of Methylmercury Controls by Existing Facilities

Phase 2 methylmercury management practices will be dependent on the findings from Phase 1 characterization and control studies. Previous studies have shown that some advance treatment and modifications of current treatment processes may be efficient at removing methyl and/or total mercury (Palmer, 2005; SJ/SC, 2007; Randall *et al*., 1999; Bosworth *et al*., 2007). Table C.9 shows the costs to implement treatment processes that could possibly be implemented by WWTPs to maximize the removal of methyl and/or total mercury in their effluent. Some WWTPs may be required to implement the advanced or additional treatment processes for other pollutants presently or in the future, so some of the costs presented in Table C.9 may entail benefits beyond compliance with the proposed amendments. The estimated annual costs per facility for implementing methylmercury controls ranges from $0/yr for modifications resulting in net zero cost, to $460,000/mgd/yr for microfiltration.

In addition, implementation of pollution minimization plans for total mercury could enable some WWTPs in the Delta and Yolo Bypass to achieve and maintain their methylmercury allocations. The proposed Basin Plan amendments require WWTPs that discharge greater than 1 mgd in the Delta, Yolo Bypass, and tributary watersheds downstream of major dams to implement pollution minimization plans for total mercury during Phase 1. WWTPs that discharge less than 1 mgd to the Delta and Yolo Bypass also could implement pollution minimization plans for total mercury to reduce effluent methylmercury levels.

Another option for dischargers to comply with concentration or load limits is to discharge a portion of their effluent to land. The cost to purchase additional land to discharge to ranges from $3,000 to $10,000/acre depending on the location of the parcel and the real estate market. In general, about 2 to 560 acres are required per 1 mgd of discharge depending on the type of land treatment process (Reed *et al.*, 1979). About 85% of NPDES-permitted WWTPs in the Delta and its tributary watersheds downstream of major dams discharge less than 10 mgd. Assuming that a WWTP discharging 10 mgd needs to reduce its methylmercury load by 50% and elects to do so by increasing its discharge to land, it would cost about $1.5 million/yr for overland flow plus rapid infiltration land treatment and about $1.9 million/yr for slow rate land treatment (e.g., using reclaimed water for agriculture, forest, or landscaping irrigation) (Reed *et al.*, 1979). Depending on the type of land treatment process (i.e., will there be any contact with the effluent by the public or will there be restricted access to the land treatment site), a facility may or may not incur cost savings for treatments that may be bypassed because the effluent is not being discharged to surface waters (e.g., nutrient removal or disinfection). It is not possible to estimate whether or not a facility would be able to bypass any treatment processes without knowing its specific treatment processes and type of land treatment proposed, so these cost estimates are not included.

Eight WWTPs in the Delta/Yolo Bypass have methylmercury allocations that require methylmercury reductions (see Table B in the proposed Basin Plan amendments at the beginning of this report). The SRCSD-Elk Grove Walnut Grove WWTP is expected to cease discharging in 2008 and is therefore not considered in the cost evaluation. One facility performs filtration (Stockton WWTP), four perform secondary clarification (Manteca, Rio Vista, Tracy and SRCSD Sacramento River WWTPs), and one makes use of lemna and oxidation ponds (Davis WWTP). The Sacramento Combined WWTP, which discharges primarily stormwater runoff during major storm events, uses primary (settling) treatment with disinfection (Table C.21). None of the facilities perform ultraviolet radiation; however, some may be required to do so in the future for the reduction of other pollutants (e.g., disinfection).

Phase 1 methylmercury characterization/control studies need to be completed to determine which types of treatment will reduce methylmercury discharges. To estimate overall potential costs to the eight WWTPs in the Delta/Yolo Bypass that must reduce their methylmercury discharges, staff assumed the following:

- Low: $580,000/yr. Assumes that implementation of total mercury minimization actions would enable compliance with the methylmercury allocations. Because six of the eight WWTPs in the Delta discharge greater than 1 mgd and therefore already would be required to implement minimization programs for total mercury (see the previous section, "4. Total Mercury Evaluation and Minimization Programs"), their potential mercury minimization costs are not included in this estimate. As noted in the earlier section, mercury minimization programs could cost about $290,000 and $400,000/yr/facility to implement [2 WWTPs x $290,000/yr = $580,000/yr].
- High: $8.4 million/yr, based on the following information and assumptions.
  - The Rio Vista WWTP (0.47 mgd) currently performs secondary clarification and could conceivably implement filtration (0.47 mgd x $460,000/yr/mgd = $216,000/yr).
  - The Sacramento Combined WWTP could conceivably upgrade to some type of chemically enhanced primary treatment (1.3 mgd x $120,000/yr/mgd = $156,000/yr).
  - The Manteca, Tracy and Davis WWTPs are expected to begin tertiary treatments between 2008 and 2015, respectively; staff assumed that tertiary treatment combined with implementation of a total mercury minimization program would enable compliance with their methylmercury allocations.
  - The one facility that currently performs filtration, Stockton WWTP, could conceivably add ultraviolet radiation (28 mgd x $36,000/mgd = $1.0 million/yr). The Stockton WWTP is the second largest municipal WWTP in the Central Valley and discharges almost 10% of all municipal effluent discharged in the Delta and its tributaries downstream of major dams.
  - The SRCSD SRWWTP currently discharges on average 162 mgd and has a permitted capacity of 181 mgd. The SRWWTP is the largest municipal WWTP in the Central Valley and discharges almost half of all municipal effluent discharged in the Delta and its tributaries downstream of major dams. The SRCSD WWTP's annual effluent methylmercury load decreased between 2001 and 2006 such that it comes within 10% of achieving the proposed allocation (Bosworth *et al.*, 2007). However, the SRCSD's 2020 Master Plan predicted that, due to population growth, the expected capacity needed by 2020 would be 218 mgd, about a 42% increase from its 2000 flow of 154 mgd (SRCSD, 2001). In addition, the California Department of Finance predicted that populations in Sacramento County will increase by 46% between 2000 and 2030, and 76% by 2050 (CDOF, 2007), which could require a SRWWTP capacity increase to about 270 mgd. SRWTP has requested to be re-rated for a capacity of about 212 mgd; the difference between 212 mgd and 270 mgd (42 mgd) and beyond is expected to require a new treatment train. If the new treatment train is constructed with a single-stage activated sludge process similar to that of the San Jose/Santa Clara WWTP

(which had a secondary effluent methylmercury concentration of 0.04 ng/l; SJ/SC, 2007), or incorporates tertiary treatment (e.g., if micro-filtration and ultraviolet radiation are needed meet Title 22 requirements; SRCSD, 2001), then no additional treatment may be necessary for 52 mgd of the projected 108 mgd expansion. In addition, SRCSD expects to expand its existing water reclamation facility capacity from 5 mgd to 40 mgd by 2021 (SRCSD, 2007). If the water reclamation facility reduces the SRWWTP's effluent discharge to the Sacramento River by 40 mgd for at least nine months of the year (30 mgd as an annual average), then the SRCSD may need to incorporate additional treatment for only about 26 mgd. The SRWTTP currently incorporates pure oxygen activated sludge aeration and secondary clarification. The SRWWTP could conceivably incorporate extended aeration ($165,656 to $378,452/yr/mgd, median = $270,000/yr/mgd) for the remainder of the volume ($270,000/yr/mgd x 26 mgd = $7.0 million/yr). Given the SRCSD's 2006/07 budget of $133.5 million for operations and $776.2 million for capital outlays (SRCSD, 2007), a $7.0 million/yr cost to comply with the proposed methylmercury allocation would represent a 5% increase in operation expenditures and a 0.8% increase in overall expenditures.

The Central Valley Water Board does not specify the method of compliance. The above assumptions are made only to estimate potential costs.

As discussed later in Section J.4, several WWTPs in upstream watersheds may need to implement methylmercury controls as part of upstream TMDLs control programs. In addition, some WWTPs may need to implement methylmercury controls as part of control programs for watersheds that are not 303(d)-Listed as mercury impaired but are required by the proposed Delta methylmercury TMDL tributary allocations to reduce their methylmercury exports. These costs are discussed separately.

Table C.9: Estimated Annual Costs to Implement Additional or Advanced Treatment Processes to Reduce Methylmercury Discharges During Phase 2.

Treatment Process	Total Annual Cost ($/mgd) [a]	
	Lower	Upper
Chemically Enhanced Primary Treatment (CEPT) [b]	$120,000	$120,000
Multimedia Filtration [b] / Dual Media Filtration [c]	$97,000	$124,000
Microfiltration [b]	$460,000	$460,000
Ultraviolet Disinfection [c, d]	$36,000	$36,000
Biological Nutrient Removal (BNR) Retrofits [e]	$0	$230,000
Additional Primary Treatment [f]	$50,128	$195,865
Additional Extended Aeration [f]	$165,656	$378,452

(a) Annual costs are based on a 20-year project life in 2007 dollars and include operation and maintenance costs, unless noted.
(b) Carollo, 2002. SRCSD Treatment Feasibility Study. Costs are based on 154 mgd and 218 mgd of treatment.
(c) SAIC, 2001. City of Vacaville, Easterly WWTP. Costs are based on 39 mgd of treatment.
(d) Reverse osmosis and ultraviolet disinfection require filtration for pretreatment. Filtration pretreatment costs not included in RO or UV costs.
(e) Randall, 1999. Costs derived from 49 WWTPs with flows ranging from 0.325 to 67 mgd. O&M costs not included.
(f) Personal communication with Anand Mamidi, Associate Water Resources Control Engineer, CVRWQCB. O&M costs not included. Costs are based on 1 mgd and 10 mgd of treatment.

6. Methylmercury Controls for New WWTPs That Begin Discharge to Surface Water During Phase 1

The proposed Basin Plan amendment requirements for new WWTPs that begin discharge to the Delta or its tributary watersheds downstream of major dams during Phase 1 are very similar to requirements for existing WWTPs:

- New WWTPs will be required to conduct effluent monitoring for total mercury and methylmercury.
- New WWTPs that have effluent methylmercury concentrations that exceed 0.06 ng/l will be required to conduct characterization and control studies (individual or collaborative).
- New WWTPs with effluent methylmercury concentrations greater than 0.06 ng/l may be required to implement methylmercury controls during Phase 2 if their effluent methylmercury loads exceed the waste load allocation reserved for new WWTPs in each Delta subarea.

As noted in earlier sections of this appendix:

- The cost of monitoring methyl and total mercury in effluent and receiving water at one facility would be about $900/month (about $11,000/yr) (Table C.7).
- The cost of a characterization/control study that evaluates five facilities is about $500,000 to $1.3 million, or about $100,000 to $260,000 for one facility.
- The cost to implement additional treatments or to increase discharges to land to decrease methylmercury discharges is about $36,000/yr/mgd (for ultraviolet radiation) to $460,000/yr/mgd (for microfiltration).

It is unknown how many new WWTPs will begin discharging to surface waters during Phase 1, or how many will have effluent methylmercury concentrations greater than 0.06 ng/l. Methylmercury monitoring results from 67 municipal WWTPs in the Central Valley (Bosworth *et al.*, 2007) indicate that 28 (~40%) of the WWTPs have effluent methylmercury levels equal to or less than 0.06 ng/l, and that facilities constructed in recent years typically have low effluent methylmercury concentrations. Therefore, to estimate the total potential costs to new facilities, staff assumed the following:

- Ten new WWTPs would begin discharging 5 mgd during Phase 1; all would be required to conduct monthly monitoring of effluent and receiving water for methyl and total mercury [10 x $11,000 = $110,000].
- Two of the new WWTPs would have effluent methylmercury concentrations greater than 0.06 ng/l and elect to conduct individual characterization/control studies [2 x ($100,000 to $260,000) = $200,000 to $520,000].
- Two of the ten new WWTPs would be required to implement additional or advanced treatment to reduce methylmercury discharges [2 x 5 mgd x ($36,000/yr/mgd to $460,000/yr/mgd) = $360,000/yr to $4.6 million/yr].

The resulting total potential cost to new WWTPs is about $200,000 to $520,000 for characterization/control studies and $470,000/yr to $4.7 million/yr for monitoring and additional/advanced treatment to reduce methylmercury discharges. Because it is unknown how many new WWTPs will begin discharging to surface waters during Phase 1, or how many will have effluent methylmercury concentrations greater than 0.06 ng/l and effluent loads greater than the waste load allocations reserved for new WWTPs in each Delta subarea, these costs are not included in Table 4.4.

D. NPDES PERMITTED MUNICIPAL SEPARATE STORM SEWER SYSTEMS

1. Urban Runoff & Receiving Water Monitoring for Methyl & Total Mercury

The proposed Basin Plan amendments require three MS4s (Sacramento, Stockton, and Tracy Area MS4s) to monitor methyl and total mercury at representative urban runoff sites and to submit the monitoring results in annual reports. No new monitoring would be required by the proposed amendments for Sacramento and Stockton Area MS4s because their NPDES permits currently require both methyl and total mercury monitoring. The Tracy MS4's NPDES permit does not currently require mercury monitoring. The cost to include methyl and total mercury monitoring into its storm water management plan is about $17,500 for the first year and $9,500/yr thereafter, assuming that three urban discharge locations and three receiving water locations are sampled three times a year. Over a thirty-year period, monitoring costs would average about $9,800/yr. Table C.10 shows the assumptions and calculations for the cost estimates associated with the proposed mercury monitoring for the Tracy MS4. The first year of new mercury monitoring will likely have higher costs because the Tracy MS4 will incur costs to update their management plan with the new mercury monitoring requirements and to amend laboratory contracts to include methyl and total mercury (80 hours x $100/hr = $8,000).

Table C.10: Potential Costs for Methylmercury and Total Mercury Monitoring for the Tracy MS4 after the First Year of Monitoring

Component	
Number of Sampling Locations:	6
Number of Sampling Events per Year:	3
Sampling Labor per Location per Sampling Event: ($140/hr for a 2 person team)	$140/hr x 1 hour per site = $140
Sampling Labor per Year:	$2,520
Water Analyses Cost per Year:	$5,202
Shipping Costs per Year for Water Samples:	$270
Total Annual Cost:	**$9,500**

2. Phase 1 Methylmercury Characterization & Control Studies

The proposed Basin Plan amendments require three MS4s (Sacramento, Stockton, and Tracy Area MS4s) to perform characterization and control studies. Ideally, some of the costs could be shared with the monitoring programs; however, as the studies become more focused, new costs would be incurred.

A previous study by the Minnesota Pollution Control Agency to determine the effectiveness of stormwater ponds and wetlands to trap total mercury and produce methylmercury cost an estimated $120,000 (Monson, 2006 & 2007), for laboratory analysis only. The study evaluated methyl and total mercury and 15 other ancillary water chemical analytes at 9 stormwater pond/wetland systems over 16 months.

The purpose of the characterization studies is to quantify the inter-annual and spatial variability of methylmercury concentrations and loading in urban runoff discharged to, or upstream of, the Delta from the three MS4 service areas. The purpose of the control studies is to determine which best management practices (BMPs) effectively reduce total mercury and methylmercury discharges. For the purpose of estimating costs for the characterization and control studies, staff assumed that the three MS4s would perform collaborative studies because it would be substantially more cost-effective to perform one collaborative set of studies than for each MS4 to perform individual studies.

The characterization studies could involve sampling urban runoff at a variety of locations throughout the three MS4 service areas that represent different land uses, soil or geologic substrates, annual rainfall amounts and storm frequencies. Characterization study costs could range from about $72,000 to $250,000, based on the assumptions outlined in Tables C.1 and C.11. The studies could include wet and dry weather monitoring upstream and downstream of existing BMPs to determine their effects on suspended sediment, total mercury, and methylmercury discharges. Also, undeveloped areas that are proposed to be developed could be monitored before and after development to determine the effect of urban development on methyl and total mercury in the runoff and the effectiveness of BMPs utilized. Control study monitoring costs could range from about $46,000 to $84,000, based on the assumptions outlined in Tables C.1 and C.12. MS4s are required by their permits to perform effectiveness studies on BMPs for other pollutants; Phase 1 control study costs could be reduced if the MS4s added methyl and total mercury and SSC analyses to current BMP effectiveness studies.

The control studies could entail modifying current BMPs or constructing new BMPs in coordination with the potential monitoring described in the previous paragraph. In 2004, Caltrans reported on its BMP Retrofit Pilot Program, where Caltrans retrofitted a number of different BMPs to determine costs and performances of the BMPs in its San Diego and Los Angeles districts (Caltrans, 2004). Because the construction costs of the retrofit program were believed to be inflated due to specific requirements of the Retrofit Pilot Program, a third-party analysis was done to make the costs comparable to other projects (Caltrans, 2001). The combined Caltrans' and other entities' median cost/acre averaged 44% less than Caltrans' costs alone. Table C.13 shows the construction costs of the BMPs that were implemented during the retrofit and the adjusted costs from the third-party analysis. While these BMPS were not designed for methylmercury control, the cost estimates are useful for determining potential BMP costs for methylmercury control.

Retrofit or construction of new BMPs at pilot urban catchment sites could range from about $0 to $760,000 based on the following assumptions:

- No BMPs were retrofitted or otherwise constructed (low estimate) or construction would take place at two urban catchments (high estimates); and
- Retrofitting a BMP or otherwise constructing a new BMP could cost as much as $380,000 per site, with two sites evaluated for the control study.

The total cost of a collaborative MS4 characterization and control study (for all three MS4s combined) could range from about $120,000 to $1.1 million.

Table C.11: Assumptions for MS4 Characterization Study Cost Estimates

Study Component	Low Estimate	High Estimate
# of Sites	5	15
# of 8-hours Days to Conduct 1 Sampling Event	1	3
# of Sampling Events	4 per year for 4 years	6 per year for 4 years
Cost per Water Sample for TotHg, MeHg, and SSC Analyses + 20% for Field & Laboratory QA	$377	$377
# of Hours for Study Design, Data Analysis, and Report Writing	240	360
TOTAL ESTIMATED COSTS [(a)]	**$72,080**	**$252,360**

(a) Additional sampling and analysis cost assumptions are detailed in Table C.1.

Table C.12: Assumptions for MS4 Control Study Monitoring Cost Estimates

Study Component	Low Estimate	High Estimate
# of BMP Sites with Upstream & Downstream Monitoring	5	10
# of 8-hours Days to Conduct 1 Sampling Event	1	2
# of Sampling Events	10	10
Cost per Water Sample for TotHg, MeHg, and SSC Analyses + 20% for Field & Laboratory QA	$377	$377
# of Hours for Study Design, Data Analysis, and Report Writing	160	240
TOTAL ESTIMATED COSTS [(a)]	**$46,050**	**$84,100**

(b) Additional sampling and analysis cost assumptions are detailed in Table C.1.

Table C.13: Construction Costs Associated with the Caltrans BMP Retrofit Pilot Program and Costs Adjusted by a Third-party Analysis.

BMP Technology	Caltrans Retrofit			Other Entities and Caltrans Retrofit Combined [a]	
	Average Total Construction Cost	Average Operation and Maintenance Cost	Median Construction Cost per Acre Contributing Area	Median Construction Cost per Acre Contributing Area	Annual Construction and O&M Cost [b]
Wetland	--	--	--	$4,586	--
Extended Detention Pond	$216,025	$3,902	$78,669	$5,438	$758
Wet Pond	$560,784	$21,235	$211,695	$7,906	$1,465
Continuous Deflection Separators	$50,434	$4,648	$28,086	$12,098	$2,660
Compost Filter	--	--	--	$12,526	--
Infiltration Trench	$182,780	$3,327	$169,525	$18,399	$1,010
Austin Sand Filter	$303,644	$3,639	$285,687	$41,591	$1,986
Bioretention Filter	--	--	--	$57,720	--
Swale	$72,307	$3,439	$112,664	$73,712	$3,752
Infiltration Basin	$193,981	$3,902	$93,684	$93,684	$10,238
Delaware Sand Filter	$287,819	$3,639	$669,761	$172,603	$3,379
Storm-Filter™	$381,877	$9,530	$261,749	$184,726	$15,485
Multi-chamber Treatment Train	$344,685	$8,016	$363,780	$363,780	$19,239

(a) The retrofit costs cited in Caltrans' retrofit study (Caltrans, 2004, final report) were believed to be inflated because of extra costs due to specific requirements of the Retrofit Pilot Program. A third party analysis of the costs was completed so that adjusted costs could be applicable to other projects (Caltrans, 2001). Other entities' costs, used for the third party analysis, were adjusted to Los Angeles, CA. All costs were adjusted to 2007 dollars.

(b) Annual costs are based on 30-year project life.

3. Methylmercury Concentration Limits

The proposed performance-based methylmercury concentration limits for the Sacramento, Stockton, and Tracy Area MS4s are to be based on data derived from conditions that represent normal operational conditions. MS4s are required to maintain the functionality of BMPs to MEP and to minimize the short-term and long-term impacts on receiving waters from new development and significant redevelopment. Any exceedance of the concentration limits would represent a material change in conditions (e.g. temporary or permanent failure of a BMP or new developments or change in land use), and the identification of possible sources of the change or the submission of a control strategy would not be a new requirement. However, the cost to sample and analyze methyl and/or total mercury in addition to current parameters would be new. The cost of new accelerated mercury monitoring could be about $5,300 to $11,000 per exceedance. It is unknown how many exceedances could occur at different MS4 discharge locations; as a result, these cost estimates are not included in Table 4.4. However, staff expects that exceedances would occur infrequently.

4. Pollution Control and Best Management Practices for Total Mercury

Because mercury is attached to sediment, BMPs to control erosion and sediment transport will be effective in reducing mercury discharges. All MS4s currently are required to implement BMPs to the maximum extent practicable (MEP) to control erosion and sediment transport; hence, so no new costs will be associated with these requirements of the proposed Basin Plan amendments.

The proposed Basin Plan amendments also require the Sacramento, Stockton and Tracy MS4s to each submit a mercury plan and implement total mercury pollution prevention measures and BMPs to the maximum extent practicable, which could incur new costs. The mercury plans should include a description of the discharger's existing mercury control efforts, a description of all mercury sources contributing, or potentially contributing, to the mercury loading in MS4 discharges, and an analysis of potential prevention and control actions that could minimize mercury loading. While mercury-specific BMPs have not yet been identified, several pollution prevention measures specific to mercury have been employed in California and elsewhere in the United States:

- Thermometer exchange and fluorescent lamp recycling programs;
- Public education and outreach on disposal of household mercury containing products and replacement with non-mercury alternatives.
- Education of auto dismantlers on how to remove, store, and dispose of mercury switches in autos.
- Enhancement of household hazardous waste collection programs to better address mercury-containing waste products (potentially including thermometers and other gauges, batteries, fluorescent and other lamps, switches, relays, sensors and thermostats).
- Survey of use, handling, and disposal of mercury-containing products used by the Sacramento, Stockton and Tracy permittee agencies and development of a policy and time schedule for eliminating the use of mercury containing products by the permittees.

A recent survey completed for the SWRCB evaluated the costs of stormwater programs of six cities identified by RWQCB staff as demonstrating meaningful progress towards maximum extent practicable compliance (Currier, 2005). This evaluation included the costs for "Public Education and Outreach and Public Involvement and Participation". Public outreach and education activities included, but are not limited to, homeowner education on trash management and proper hazardous waste disposal, hazardous waste collection events, educational displays, pamphlets, and booklets, and pollution prevention for businesses. Public involvement and participation activities included storm drain marking, stream cleanups, volunteer monitoring, and community hotlines. The combined cost for Public Outreach and Participation ranged from $32,000 to $410,000/yr/municipality; however, these costs include the costs for efforts for all pollutants.

The USGS reviewed costs for individual activities that could be used in mercury reduction programs. For example, fluorescent light recycling programs cost about $34/lb of mercury or $0.57/light, and mercury thermometer exchange programs cost from $4 to $17 per thermometer (Wood, 2003). Over a two-year period, the Palo Alto mercury collection program collected nearly 73 lb of mercury, including 1,784 thermometers and 4,310 fluorescent lights (Wood, 2003; Weiss, 2003). Using Wood's 2003 unit cost estimates and Palo Alto's collection results, a fluorescent light recycling program could cost about $1,200/yr, and a thermometer exchange program could cost about $3,600/yr to $15,000/yr.

The Sacramento and Stockton MS4 permits require the permittees to implement mercury control plans that include pollution prevention measures like those described above. Therefore, mercury control plans are a new requirement only for the Tracy MS4. New costs for the Tracy MS4 to develop and implement a mercury plan would be about $11,000/yr to $46,000/yr, based on the following:

- The cost to develop and submit a mercury plan to the Board would be about $24,000 [240 hours x $100/hour]. Averaged over 30 years, this would be about $800/yr.
- The cost to implement and evaluate pollution prevention measures and BMPs for mercury could range from about $6,000 to $41,000/yr, given the cost estimates for thermometer exchange and fluorescent light recycling programs and assuming that the addition of mercury-specific actions will not cost more than 10% of the total Public Education and Participation Programs described in the previous paragraph.
- The cost to submit an annual report to the Board describing the actions taken during the past year, effectiveness evaluations completed that year, and actions planned for the next year would be about $48,000/yr to $72,000/yr [40 hours x $100/hour].

Costs incurred by the Tracy MS4 could be substantially reduced if it coordinated pollution prevention efforts with the other NPDES-permitted MS4s and WWTPs in its region (e.g., the SRCSD, Stockton, Lodi, and Tracy WWTPs).

5. Phase 2 Implementation of Methylmercury Management Practices

The proposed Basin Plan amendments require several large and small MS4s to reduce their methylmercury discharges to the Delta/Yolo Bypass. Until the proposed Phase 1 methylmercury characterization/control studies are completed, it is impossible to know which MS4s will implement which types of BMPs to reduce their methylmercury discharges. It may be possible to make substantial reductions in methylmercury discharges through the implementation of pollution prevention measures for total mercury and BMPs currently available.

As described earlier, pollution prevention measures can include thermometer exchange and fluorescent lamp recycling programs, enhancement of household hazardous waste collection programs, and implementation of public and industry education and outreach on disposal of household mercury containing products and replacement with non-mercury alternatives and on proper removal, storage, and disposal of mercury switches in autos and other industrial equipment. The proposed Basin Plan amendments require the Sacramento, Stockton and Tracy MS4s to implement pollution prevention measures for total mercury [4] during Phase 1. As one component of complying with their methylmercury allocations, small MS4s also could implement pollution prevention measures during Phase 2. Small MS4s with allocations that require

[4] As noted in Section C.3, implementation of pollution prevention measures for total mercury is already a baseline requirement in the NPDES permit for the Sacramento MS4. The proposed Stockton MS4 permit (to be considered by the Central Valley Water Board in fall 2007) also contains provisions for a mercury control plan.

methylmercury load reductions Delta include the cities of Lathrop, Rio Vista, and West Sacramento, as well as the Port of Stockton, San Joaquin, Solano, and Yolo counties. Based on the assumptions described in Section C.4, if small MS4s implement pollution prevention measures to comply with their methylmercury allocations, costs could range from about $56,000/yr to $350,000/yr. Costs incurred by the small MS4s could be substantially reduced if they coordinated pollution prevention efforts with the NPDES-permitted WWTPs in their region.

In addition, modification of storm water collection and retention systems could reduce methylmercury production. For example, it is conceivable that installation of aerators in basins could promote degradation of methylmercury in the water column. Assuming a detention basin surface area of 10 acres, it could cost about $25,000 to $50,000 to install basin aerators and $150/yr to $440/yr to maintain them; average annual costs over a 30-year period would about $980/yr to $2,100/yr. In addition, Table C.13 lists the costs of several commonly used BMPs ($800/yr to $19,000/yr), some of which also may be effective at reducing methylmercury discharges. Increasing the frequency of sediment removal from detention basins (already a common maintenance practice) may further reduce the supply of inorganic mercury available for methylation. Additional methylmercury control options that involve improvements to the storm water collection and retention systems may be evaluated by the Phase 1 characterization and control studies.

There are hundreds of urban discharge points in the Delta/Yolo Bypass; which areas discharge the most methylmercury and which areas could have feasible and cost-effective methylmercury management practices is not known. Phase 2 methylmercury management practice implementation costs could range from about $83,000/yr to $260,000/yr based on the following assumptions:

- The small MS4s maintain their methylmercury allocations by implementing pollution prevention measures for total mercury, coordinated with the WWTPs in their regions [$56,000/yr to $200,000/yr].
- In addition to implementing mercury control plans as described in Section C.4, the large MS4s implement control actions at about 25% of their urban catchments in the Delta, which could cost $800/yr to $1,500/yr at 15 locations, $1,500/yr to $5,000/yr at 3 locations, and $5,000 to $10,000 at 2 locations [$26,500/yr to $57,500/yr].

As discussed later in Section J.4, several MS4s may be required to implement additional methylmercury management practices in upstream watersheds as part of upstream TMDLs control programs. In addition, some MS4s may need to implement methylmercury controls as part of control programs for watersheds that are not 303(d)-Listed as mercury impaired but are required by the proposed Delta methylmercury TMDL tributary allocations to reduce their methylmercury exports. These costs are discussed separately in Section J.

E. WETLANDS

1. Monitoring Program for Irrigated Agriculture and Wetlands

The proposed Basin Plan amendments require a monitoring program for irrigated agriculture and wetlands in all Delta/Yolo Bypass subareas that require methylmercury source reductions to comply with proposed methylmercury allocations.[5] The monitoring program would be developed as a component of the Phase 1 methylmercury studies described in Section D.2, and would not be implemented until after the Phase 1 studies were completed. The goal of the monitoring would be to determine subarea allocation compliance by summing of annual methylmercury loads from the multitude of agriculture and wetland areas in each subarea for comparison to the subarea allocations. The monitoring program should assess the variety of wetland and agriculture types in the Delta/Yolo Bypass and establish periodic monitoring at representative sites. Monitoring would evaluate irrigation/source water, discharge and receiving water volumes and methylmercury concentrations at a frequency that addresses seasonal variability and varying management practices throughout the year. Water Quality Coalitions established under the Irrigated Lands Program (ILP) currently have monitoring programs that evaluate surface waters that receive discharges from agricultural and wetland areas in the Delta/Yolo Bypass, but those programs do not include analyses for methylmercury, nor sampling of irrigation or discharge waters except when special studies are conducted. Hence, a reasonably foreseeable method of compliance with the monitoring requirements for wetlands and agriculture would be for the existing ILP monitoring programs to add methylmercury analyses to their current receiving water monitoring locations and to incorporate additional monitoring locations representative of discharges from the variety of wetland and agriculture types in the Delta/Yolo Bypass.

Currently, the Water Quality Coalitions[6] monitor 13 sampling locations in the Delta/Yolo Bypass 8 times per year. Adding methylmercury analyses to the ILP monitoring program at these 13 locations could cost approximately $28,400/yr. If 6 new sampling locations were added to the ILP monitoring program for methylmercury analysis, the additional annual cost could cost about $20,500/yr (see Table C.14). Therefore, the annual monitoring cost for irrigated agriculture and wetlands utilizing the monitoring program established in the ILP could range from about $28,000/yr to $50,000/yr. These costs are split evenly between the wetlands and agricultural sections of Table 4.4 ($14,000/yr to $25,000/yr for each).

---

[5] Subareas that require methylmercury source reductions to protect humans and wildlife that consume local fish include the Yolo Bypass, Sacramento, San Joaquin, Mokelumne, and Marsh Creek subareas. Irrigated agriculture and wetlands in the Central and West Delta subareas would require monitoring only if wetland restoration projects or widespread changes in agricultural crops or practices were to take place. Refer to the following section in Chapter 4 of the Basin Plan Amendment Staff Report, “4.3.12. Actions to Minimize Methyl and Total Mercury from New or Expanded Sources”.

[6] The coalition groups and individual dischargers that perform monitoring in the Delta/Yolo Bypass include the San Joaquin County and Delta Water Quality Coalition, the Sacramento Valley Water Quality Coalition, and the South San Joaquin Irrigation District.

2. Phase 1 Methylmercury Characterization & Control Studies

A Delta-wide methylmercury characterization study for wetlands should evaluate seasonal patterns in methylmercury production in and discharges from a suite of wetland types. A follow-up methylmercury control study should focus on those wetland settings that have the greatest net methylmercury input to Delta waterways. To increase the efficiency and reduce the cost of the studies, it is recommended that responsible parties develop collaborative studies that coordinate between existing wetlands and sites where wetland restoration activities are expected to be completed during Phase 1. The cost estimates below assume that responsible parties coordinate their efforts amongst each other and with agencies responsible for flooding in the Yolo Bypass.

Table C.14: Cost Estimates for Additional Irrigated Lands Program Monitoring.

Component	Assumptions and Costs for Adding MeHg Analyses to Existing Sampling Locations	Assumptions and Costs for Adding New Sampling Locations for MeHg Analyses
Number of Sampling Locations	13	6
Number of Sampling Events per Year	8	8
Labor - Admin Cost per Year [a]	$6,000	$4,000
Labor - Water Sampling Cost per Year [b]	$1,213	$6,720
Water Analyses Cost per Year [c]	$20,717	$9,562
Shipping Costs per Year for Water Samples [d]	$480	$240
Total Annual Cost	**$28,410**	**$20,522**

(a) Staff assumed that modifying laboratory contracts and sampling plans, data analyses, report writing and other administrative tasks related to the addition of methylmercury analysis to the existing ILP monitoring program would require 60 hours at $100/hr. Staff assumed that the addition of new sampling locations to the existing ILP monitoring program would require an additional 40 hours at $100/hr.

(b) Staff estimated that a two-person sampling crew at $140/hr would require an additional 5 minutes per site to collect additional sample volume for methylmercury analysis at currently-monitored sites (5/60 x 13 x 8 x $140/hr) and one hour per site for new sampling sites (1 x 6 x 8 x $140/hr).

(c) Methylmercury analysis costs include an additional 20% for field and laboratory QA samples at existing monitoring sites ($166/sample x 13 x 8 x 1.2) and new ($166/sample x 6 x 8 x 1.2) monitoring sites.

(d) Shipping cost assumes samples collected for MeHg analysis at new and existing monitoring sites would be shipped together and would require one large cooler per sampling event at $90 per large cooler ($90 x 8 = $720, split proportionally between existing ($480) and new ($240) locations based on the number of sampling locations.)

Characterization study costs for wetlands throughout the Delta and Yolo Bypass could range from about $950,000 to $1.4 million, based on the following assumptions:

- Sampling would take place at 8 to 12 sites. The sites should represent a range of water regimes (e.g., flooding duration, depth, timing, water residence time, and tidal influence), vegetation types and densities, source water characteristics, soil substrate characteristics, and surface sediment mercury concentrations. In addition, sites should include wetlands immersed by flood flows within the Yolo Bypass.[7] Staff assumed that a two-person sampling team could sample four sites per 8-hour day at $140/hr.

- Three years of sampling would take place, including 36 monthly water-sampling events plus six sampling events that target significant hydrologic changes (e.g., first flood of the year), for a total of 42 sampling events.
- For each sampling event, two samples would be collected per site, characterizing the input and export water.
- The following water analyses would be performed for each sample: filtered and unfiltered methyl and total mercury, total sulfate, filtered and unfiltered sulfide, dissolved and total organic carbon (DOC and TOC), and suspended sediment concentration (SSC). Analysis costs would include an additional 20% for field and laboratory QA samples.
- One sediment-sampling event would take place at each site each year over the three-year sampling period. At each site, three samples would be collected and analyzed per sampling event. Staff assumed that a two-person sampling team could sample four sites per 8-hour day at $140/hr.
- The following sediment analyses would be performed for each sample: inorganic mercury concentration, methylmercury concentration, sulfite/sulfate concentration and moisture content/density.
- Study design, data analyses, report writing, and administration would entail 40 hours per site at $100/hr.

The above cost estimate assumes that no other characterization studies have been completed. However, several CALFED and other studies will have been completed by the time the proposed Phase 1 studies commence, and incorporation of their results could enable the Phase 1 wetland characterization study to evaluate fewer sites. Assuming that 4 to 10 sites are evaluated (rather than 8 to 12 sites), characterization study costs could range from about $490,000 to $1.2 million. This cost estimate is comparable to previous wetland methylmercury characterization studies, which, when standardized to a three-year study period for ten wetlands, entailed costs between $1.0 million to $1.9 million (MLML, 2006; PWA, 2006; J. Cain, 2006).

Previous control studies cost between $243,000 and $920,000 for a three-year study involving four wetlands (MLML, 2006). For the sake of estimating potential costs, staff assumed that another control study that evaluates four wetlands would be necessary to adequately develop management practices for wetlands identified by the above-mentioned characterization study as substantial methylmercury producers. If characterization study costs range from about $490,000 to $1.9 million, and control study costs range from $240,000 to $920,000, overall study costs could range from about $730,000 to $2.8 million.

[7] The proposed Basin Plan amendment require that water management agencies responsible for flooding the Yolo Bypass and landowners within the bypass conduct a characterization study of methylmercury production and discharge from lands immersed by managed flood flows within the bypass. See Section F for more discussion.

3. Methylmercury Management Practices for New Wetland Restoration Projects Constructed during Phase 1

The Record of Decision (ROD) for the California Bay-Delta Authority commits it to restore 30,000 to 45,000 acres of freshwater, emergent tidal wetlands, 17,000 acres of freshwater, emergent non-tidal wetlands, and 28,000 acres of seasonal wetlands in the Delta by 2030 (CALFED Bay-Delta Program, 2000a & 2000c). The proposed Basin Plan amendments require new wetland restoration projects completed during Phase 1 that have the potential to increase methylmercury loading to the Delta/Yolo Bypass to:

- Either participate in a comprehensive methylmercury characterization and control studies as described earlier in Sections 4.3.7 and 4.3.8, or implement a site-specific monitoring and study plan;
- Evaluate practices to minimize methylmercury discharges; and
- Implement newly developed management practices, as feasible, with monitoring to demonstrate effectiveness of management practices.

As noted in the previous section, staff assumed that managers for proposed wetland restoration activities to be completed during Phase 1 would collaborate with managers for existing wetlands to complete characterization and control studies. If there were an increase in surface sediment and water methylmercury concentrations due to wetland restoration that cannot be explained by pre-project seasonal variability, then during Phase 2 (after the completion of the methylmercury characterization and control studies), the project proponents would need to develop and implement management practices to reduce methylation to the extent practicable.

Preliminary results from ongoing wetland studies (see Chapter 3 in the TMDL Report) indicate that seasonal wetlands generally may be net producers of methylmercury, while permanent wetlands generally may be less productive of methylmercury or even net sinks. For this reason, staff focused on new seasonal wetlands when considering the costs of potential methylmercury management practices.

The preliminary results from ongoing wetland studies indicate that the methylmercury concentrations within some seasonal wetlands are relatively high initially and then decrease to much lower levels. Therefore, one methylmercury management practice could be to hold wetland discharge water until its monitored methylmercury levels have decreased to low levels, before discharging into surface waters. Monitoring costs could range from about $93,000/yr to $125,000/yr, based on the following assumptions:

- The Record of Decision for the California Bay-Delta Authority commits it to restore 28,000 acres of seasonal wetlands in the Delta by 2030 (CALFED, 2000). Assuming that 20% of this acreage would be restored during Phase 1, and that holding the discharge water would be a reasonable methylmercury management practice for 25% of the restored acreage, this method would be used for 1,400 acres of new seasonal wetlands.
- Methylmercury monitoring would take place bi-weekly for 2 to 3 months for a total of 4 to 6 sampling events per year.

- There would be three sampling locations for every 100 acres of seasonal wetland, for a total of 42 locations. Staff assumed that a two-person sampling team could sample six sites per 8-hour day at $140/hr.
- Each sample would be analyzed for total methylmercury ($166/sample), with an additional 20% cost per sampling event for field and laboratory QA samples.
- Data analyses, report writing, and administration would entail 20 hours per 100-acre wetlands at $100/hr.

If it is necessary for water to be released from managed wetlands before the methylmercury concentration decreases to lower levels, the water could be discharged to another existing wetland or other detention area until the methylmercury concentration decreases to acceptable levels. Methylmercury concentrations would need to be monitored to determine when the water could then be discharged to surface waters; the costs for monitoring would be consistent with the estimates outlined above. The cost for transferring water between managed wetlands is expected to be minimal or zero.

As noted in Chapter 4, methylmercury management practices could involve modifying water depths, flooding frequency and/or duration, vegetation types and density, and source waters. Additional methylmercury management practices that involve wetland design modifications may be evaluated by the proposed Phase 1 characterization and control studies.

4. Phase 2 Implementation of Methylmercury Management Practices for Existing Managed Wetlands

The implementation of Phase 2 methylmercury management practices is dependent on the findings from Phase 1 characterization and control studies. For now, staff assumed that the reasonably foreseeable methods of compliance for Phase 2 methylmercury management practices are the same as those described for new wetland restoration projects constructed during Phase 1 (see Section D.3).

Subareas that require methylmercury source reductions to protect humans and wildlife that consume local fish include the Yolo Bypass, Sacramento, San Joaquin, Mokelumne, and Marsh Creek subareas. According to the USFWS National Wetlands Inventory (USFWS, 2006), about 11,800 acres of seasonal wetlands occur in these subareas. Staff assumed that holding the discharge water until methylmercury levels dropped would be a reasonable management method for 25% of the existing seasonal wetland acreage. This acreage assumption, combined with the cost assumptions described in Section D.3 and Table C.1 at the beginning of this appendix, result in a cost range of about $200,000/yr to $270,000/yr.

F. AGRICULTURAL LANDS

1. Monitoring Program for Irrigated Agriculture

As noted in Section D.1, the proposed Basin Plan amendments require a monitoring program for irrigated agriculture and wetlands in all Delta/Yolo Bypass subareas that require methylmercury source reductions to comply with proposed methylmercury allocations. The annual monitoring cost for irrigated agriculture and wetlands utilizing the monitoring program established in the ILP could range from about $28,000/yr to $50,000/yr. These costs are split evenly between the wetlands and agricultural sections of Table 4.4 ($14,000/yr to $25,000/yr for each). See Section D.1 for an explanation of how the potential monitoring costs were calculated.

2. Phase 1 Methylmercury Characterization & Control Studies

A Delta-wide methylmercury characterization study for irrigated agriculture should evaluate seasonal methylmercury production and degradation in a variety of agricultural types that discharge to those subareas that require methylmercury source reductions to protect humans and wildlife that consume local fish (Yolo Bypass, Sacramento, San Joaquin, Mokelumne, and Marsh Creek subareas). A follow-up methylmercury control study should focus on those agricultural settings that have the greatest net methylmercury input to Delta waterways. To increase the efficiency and reduce the cost of the studies, it is recommended that responsible parties develop collaborative studies. The below cost estimates assume that responsible parties coordinate their efforts amongst each other.

Characterization study costs could range from about $140,000 to $220,000, based on the cost assumptions listed in Table C.1 and the following assumptions:

- Sampling would take place at 8 to 12 sites. Sites could be representative of a variety of crop types, irrigation techniques, irrigation water sources, soil substrate characteristics, surface sediment mercury concentrations, and geographic locations (below mean sea level and upland locations). In addition, sites should include agricultural lands immersed by flood flows within the Yolo Bypass.[8] Staff assumed that a two-person sampling team could sample four sites per 8-hour day at $140/hr.
- Two years of sampling would take place, including bi-monthly water-sampling events when the fields are discharging irrigation water during the active growing season (assumed to be eight months of each year on average), with one sampling event each year targeted on the first irrigation discharge of the growing season and two storm events during the wet season that result in the discharge of stormwater rather than irrigation water, for a total of 12 sampling events over two years.
- For each sampling event during the active growing season, one sample would be collected from the input water and one sample would be collected from the export water

[8] The proposed Basin Plan amendment require that water management agencies responsible for flooding the Yolo Bypass and landowners within the bypass conduct a characterization study of methylmercury production and discharge from lands immersed by managed flood flows within the bypass. See Section F for more discussion.

at each site. (Rainwater methylmercury data available in the published literature, such reports for the ongoing CALFED studies, could be compared to methylmercury in stormwater runoff from the fields to determine whether the fields act as methylmercury source during the wet season.)

- The following water analyses would be performed for each sample: unfiltered total mercury and methylmercury and SSC ($123, $166, and $25 per sample, respectively). Analysis costs would include an additional 20% for field and laboratory QA samples.
- One sediment-sampling event would take place at each site where water is sampled and an additional 8 to 12 sites (for a total of 16 to 24 sites) during the study period to determine whether mercury-enriched soils occur within the farmed lands and drains.[9] At each site, three samples would be collected from different locations (e.g., actively farmed areas, buffer areas, and drains). Staff assumed that a two-person sampling team could sample four sites per 8-hour day at $140/hr. The sediment samples would be analyzed for inorganic mercury concentration and moisture content/density ($129 and $22 per sample, respectively, plus 20% for field and laboratory QA samples).
- Study design, data analyses, report writing, and administration would entail 40 hours per water sampling site at $100/hr.

For the control study cost estimates, staff considered two management practices that could potentially reduce the amount of methylmercury discharge from irrigated agricultural fields, micro-irrigation (drip and micro-sprinkler irrigation) and tailwater recovery systems, in addition to a previous control study conducted by USGS on rice fields in the Yolo Bypass. Staff assumed the following for the cost estimates for the control studies evaluating micro-irrigation and tailwater recovery systems:

- Sampling would take place at 4 to 8 farm sites, with a control plot and test plot at each site, and half the test plots evaluating micro-irrigation and the other half evaluating tailwater recovery systems.
- Two years of monthly water sampling during the active growing season (assumed to be eight months in each year) would take place, for a total of 16 sampling events. If there is no agricultural runoff occurs because of implementation of water management practices, then no sampling would be required.
- For each sampling event, one sample would be collected from the input water and one sample would be collected from the export water at each site.
- The following water analyses would be performed for each sample: unfiltered total mercury and methylmercury and SSC. Analysis costs would include an additional 20% for field and laboratory QA samples. Staff assumed that a two-person sampling team could sample four sites per 8-hour day at $140/hr.

---

[9] Farming began in the Delta in 1849, about the same time that gold mining began in the Sierra Nevada Mountains (DWR, 1995). In 1861, the California legislature authorized the Reclamation District Act, which allowed drainage of Delta swampland and construction of levees. The extensive Delta levee system was mostly built between 1869 and 1880 (DWR, 1995). Because hydraulic gold mining – which resulted in the transport of large amounts of mercury-contaminated silt and sand – took place until the Sawyer Decision outlawed the practice in 1884, some levees and Delta islands may have been constructed with mercury-contaminated sediment.

- Study design, data analyses, report writing, and administration would entail 40 hours per site at $100/hr, and would include an evaluation of hydrology (e.g., flow/volume of irrigation and return water).
- Management method costs would include: micro-irrigation equipment ($269 cost per acre per year); tailwater recovery system installation ($481-$550 per acre) and annual operations and maintenance ($12-$13 per acre). The average control and test plot size was assumed to be 75 acres.

A two-year control study based on the above assumptions could cost about $290,000 to $600,000. This cost estimate is less than, but still comparable to, costs associated with a control study that is currently in progress. The USGS methylmercury control study in rice fields cost about $230,000 for a three-year study involving one rice field (MLML, 2006). If this estimate were scaled up to four and eight fields, and scaled down to two years, to be consistent with the hypothetical studies, the cost estimate for the USGS study would range from about $613,000 to $1.2 million. The USGS study costs more because it involves analyses not needed to comply with the proposed Basin Plan amendment study requirements.

The overall cost estimates for the characterization and control studies for irrigated agriculture range from about $430,000 to $820,000.

3. Phase 2 Implementation of Methylmercury Management Practices for Irrigated Agriculture

The implementation of Phase 2 methylmercury management practices is dependent on the findings from Phase 1 characterization and control studies. To evaluate potential implementation costs, staff considered two potential management practices to control the discharge of methylmercury from irrigated agricultural fields to surface waters. The two management practices considered are tailwater recovery systems and micro-irrigation, which includes drip- and micro-sprinkler irrigation. The mechanism of both practices is to reduce or eliminate the volume of discharge from agricultural lands, thereby reducing methylmercury loads to surface waters. Annual costs could range from about $220,000/yr to $460,000/yr. Both management practices could result in benefits beyond potential compliance with the proposed Delta methylmercury Basin Plan amendments. Other water quality problems could be alleviated by reducing or eliminating agricultural discharge to receiving waters. In addition, micro-irrigation and tailwater recovery systems may reduce the amount of water needed for irrigation, resulting in cost savings. The cost estimates do not include these benefits and cost savings.

Micro-irrigation. Micro-irrigation, including drip- and micro-sprinklers, can be used for a variety of crop types including orchards, vineyards, and row crops. Staff estimated costs for irrigation system conversion of orchards and vineyards in the Delta and Yolo Bypass from flood irrigation to micro-irrigation. Flood irrigation is considered the baseline condition for orchards and vineyards. The cost estimates for installing and using a micro-irrigation system are well documented for orchards. The University of California Cooperative Extension (2002) calculated the costs to establish an almond orchard using either micro-sprinkler or flood irrigation systems. The estimated annual cost for the installation and operation and maintenance for a flood irrigation system is $42 per acre/yr (UCCE, 2002a) and $269 per acre/yr for micro-irrigation

(UCCE, 2002b). The cost differential for a micro-irrigation system compared to flood irrigation, the baseline condition, is $227 per acre/yr.

In order to estimate costs of micro-irrigation conversion in the orchards and vineyards in the entire Delta and Yolo Bypass, it is necessary to determine the acreage of farms that are using the baseline condition, flood irrigation in the subareas that require methylmercury source reductions to protect humans and wildlife that consume local fish (Yolo Bypass, Sacramento, San Joaquin, Mokelumne, and Marsh Creek subareas). Staff used the California Department of Water Resources Land Use data to determine the acreage of orchards and vineyards in those subareas, as well as the acreage of those farms using flood irrigation. Of the approximately 12,200 acres of orchards in those subareas, 1,350 acres are irrigated by flood irrigation (DWR, 1994-2006). As for vineyards, 3,600 acres of the total 59,200 acres are irrigated by flood irrigation (DWR, 1994-2006). Staff assumed that micro-irrigation would be installed where the characterization study results indicate there are elevated methylmercury concentrations in return water and/or where there are elevated mercury levels in soil. If about 10% to 20% all of the orchards and vineyards using flood irrigation converted to micro-irrigation (about 495 to 990 acres), the annual cost could range from about $110,000/yr to $220,000/yr.

Tailwater Recovery Systems. Tailwater recovery systems are designed to collect and reuse the irrigation runoff or tailwater from agricultural fields. These collection systems are most commonly associated with surface flood irrigation because flood irrigation results in tailwater runoff. In many subsided Delta islands, where the elevation is below mean sea level and the groundwater table is high, water is pumped off of the agricultural fields to prevent the root zone of the crops from being starved of oxygen by too much water. Tailwater recovery systems would not be appropriate for such situations. Only the upland areas where surface flood irrigation is used would be applicable to tailwater recovery systems.

The Legal Delta map in the DWR Sacramento-San Joaquin Delta Atlas defines the areas of the Delta that are upland (above 5 feet mean sea level) and lowland (below 5 feet) (DWR, 1995). Staff used this definition in conjunction with DWR Land Use data (1994-2006) to determine that approximately 47,000 acres of agricultural lands are irrigated with flood irrigation in upland areas of the Delta/Yolo Bypass subareas that require methylmercury source reductions. According to the USDA Farm and Ranch Survey (2004), approximately 16% of flood-irrigated lands utilize tailwater recovery systems in California. Staff applied the same percentage to the upland areas of the Delta/Yolo Bypass that require methylmercury source reductions. Approximately 39,500 acres of flood-irrigated agricultural lands in the upland areas of those Delta/Yolo Bypass subareas may not currently use tailwater recovery systems but possibly could.

Installation costs for tailwater recovery systems range from $481 to $550 per acre (Schwankl, 2007). This estimate includes the costs for construction, equipment, and labor. The estimated annual cost for operation and maintenance is $12 to $13 per acre (Schwankl, 2007). Staff assumed that tailwater recovery systems would be installed where the characterization study results indicate there are elevated methylmercury concentrations in return water and/or elevated mercury levels in soil. If about 10% to 20% of agricultural lands in upland areas currently using flood irrigation installed tailwater recovery systems (about 4,000 to 8,000 acres), it would cost about $1.9 million to $4.4 million for installation and about $48,000/yr to $100,000/yr to maintain the systems (about $110,000/yr to $240,000/yr when averaged over a 30-year period).

G. NEW YOLO BYPASS FLOOD CONVEYANCE PROJECTS

Changes in Yolo Bypass flood conveyance could include new or modified weirs in the Yolo Bypass and changes to the *Central Valley Project – Operations Criteria and Plan, 30 June 2004* (CVP-OCAP) that result in increased flows, flood frequency, or flood duration in the Yolo Bypass. The proposed Basin Plan amendments require agencies that propose changes to the Yolo Bypass flood conveyance that could increase methylmercury or total mercury loading to the bypass do the following:

- Complete characterization studies to determine baseline conditions prior to project completion;
- Evaluate potential negative impacts of project alternatives on ambient mercury and/or methylmercury levels; and
- Develop mitigation measures for alternatives that would increase ambient mercury and/or methylmercury levels.

In addition, the proposed amendments recommend that water management agencies responsible for flooding the Yolo Bypass and landowners within the bypass conduct a collaborative characterization study of methylmercury production and discharge from lands immersed by managed flood flows within the bypass. Potential study and implementation costs are discussed below.

1. Baseline Characterization Study Prior to Implementation of New Projects

Staff assumed that water management agencies responsible for flooding the Yolo Bypass would coordinate with landowners within the bypass to conduct Phase 1 characterization studies of methylmercury production and discharge from agricultural lands and wetlands immersed by managed flood flows within the bypass (see Sections D.2 and E.2). Costs for a baseline characterization study to evaluate open-water habitat and other lands immersed by flood flows (prior to implementation of new flood conveyance projects) could range from about $160,000 to $310,000, based on the following assumptions:

- Sampling would take place at 4 to 8 sites. The study sites would include open-water habitats and upland areas not addressed by the wetland and agricultural characterization studies. Staff assumed that a two-person sampling team could sample four sites per 8-hour day at $140/hr.
- Two years of sampling would take place, including 8 quarterly water-sampling events plus 12 sampling events that target significant hydrologic changes (e.g., rising and falling limbs of the flood hydrograph for spills from Fremont and Cache Creek Settling Basin weirs), for a total of 20 sampling events.
- The following water analyses would be performed for each sample: filtered and unfiltered methyl and total mercury, total sulfate, filtered and unfiltered sulfide, total and dissolved organic carbon (TOC and DOC), and suspended sediment concentration (SSC). Inductively coupled plasma analysis (ICP) to identify the sources of water sampled (e.g., Cache Creek or Sacramento River) would be performed twice for each sampling location

each year. Analysis costs would include an additional 20% for field and laboratory QA samples.

- Study design, data analyses, report writing, and administration would entail 40 hours per site at $100/hr.

2. Methylmercury Control Studies for New Projects

Changes to the Yolo Bypass flood conveyance could result in increased flows, flood frequency, or flood duration in the Yolo Bypass. Until a particular flood conveyance project is proposed, it is difficult to determine the necessary components of a study to evaluate how those changes could affect total mercury and methylmercury levels in the bypass and ways to mitigate negative impacts. Potential questions to guide the study could include, but not be limited to, the following:

- How would the proposed project change the flows, flood frequency, and flood duration in the Yolo Bypass?
- How would the mercury characteristics of the water sources to the bypass change? For example, depending on the source of the additional floodwater (Sacramento River above Colusa versus Feather River), would the water have higher methylmercury concentrations or higher suspended sediment mercury concentrations?
- Which areas in the bypass would be subject to any new inundation (e.g., lands not previously inundated by typical spills from Fremont Weir)? Which areas in the bypass would be subject to longer or shorter periods of inundation? Given the results from the baseline characterization studies, how would the inundation changes affect methylmercury discharges from the inundated land?
- Could the new project result in increased deposition or erosion in the bypass? If so,
  - How would the inorganic mercury concentration of the newly deposited (or newly exposed) sediment compare to existing surface sediment mercury concentrations in the affected areas? How would this affect methylation rates in the affected sediments and methylmercury discharges from the affected areas?
  - How would any changes to past deposition/erosion patterns affect total mercury loading to the western Delta and San Francisco Bay, compared to pre-project conditions for the Sacramento Basin (Yolo Bypass and Sacramento River) total mercury exports?
- How could floodwater be managed to have minimal or no impact to total mercury or methylmercury levels?

These questions likely could be addressed by a combination of several study tasks:

1. Hydrologic and geomorphic modeling of flow scenarios;
2. Review of the Phase 1 characterization and control study results for wetland and open-water areas in the Yolo Bypass described in previous sections, published literature and available data for methylmercury and total mercury levels in Yolo Bypass sediments and bypass source waters; and
3. Laboratory studies that evaluate how changing sediment characteristics could affect methylmercury production and flux rates.

Task 1 would almost certainly take place for any proposed change to Yolo Bypass flood conveyance; therefore this is not expected to result in new modeling costs. A careful compilation and synthesis of existing literature and water/sediment data would likely require about 80 to 160 hours of effort, which, assuming a rate of $140/hr, could cost $11,200 to $22,400.

Depending on the results of the Phase 1 characterization and control studies and Task 2 synthesis, additional field sampling – e.g., collecting surface and buried sediment samples from current depositional areas and potential erosional areas in the Yolo Bypass and samples from tributary watershed areas expected to act as sources of new surface sediment in the bypass – and laboratory experiments may be needed to evaluate how changing sediment characteristics could affect methylmercury production. A sediment spiking study could cost about $75,000 to $100,000, including the collection of two *in situ* intact cores from the top 12 inches of sediment from three to six locations four times throughout a year, and analysis of the cores before and after laboratory sediment spiking for (a) sediment total mercury, methylmercury, and sulfite/sulfate, and (b) sediment pore water methylmercury concentration gradients.

To develop a range of potential methylmercury characterization and control costs for new Yolo Bypass flood conveyance projects, staff assumed that two new projects would occur during the 30 years after the effective date of the proposed Basin Plan amendments that would conduct two literature reviews (2 x [11,200 to $22,400]) and one sediment spiking study ($75,000 to $100,000). Post-project implementation monitoring – with the same assumptions used to estimate costs for the baseline characterization monitoring described in the previous section but applied to four sites, including open-water sites and any wetlands or agricultural areas affected by the project – would be conducted for both projects (2 x $156,000). The resulting potential costs could range from about $410,000 to $460,000.

3. Implementation of Methylmercury Management Practices for New Projects

Until the Phase 1 characterization and control studies are completed for wetland and open-water areas in the Yolo Bypass, and the potential effects of a new flood conveyance project evaluated, it is not known which methylmercury management practices could be applicable to new flood conveyance projects. However, methylmercury management practices for the Yolo Bypass flood conveyance conceivably could include:

- Active remediation or removal of mercury contaminated sediment within the Yolo Bypass downstream of the Cache and Putah Creek watersheds; and
- Modification of the channel geometry to route more water down the eastern side of the bypass (away from sediment inputs from the Cache and Putah Creek watersheds).

A potential remediation project could focus on the mercury-contaminated sediment deposited downstream of the Cache Creek Settling Basin and upstream of Interstate 5, where the bypass narrows because of the curve of the Sacramento River and flow is further slowed by the Northern Railroad trestle (Figure C.2). Sediment excavation costs could range from about $390,000/yr to $770,000/yr, based on the following assumptions:

- An area of 2,400 by 3,600 feet is excavated to a depth of 2 feet, resulting in the removal of about 640,000 cubic yards of sediment and construction of a small earthen weir on the downstream side of the area;
- Excavating the sediment costs about $6 to $12 per cubic yard;
- Administration effort would entail 160 hours per excavation event at $100/hr; and
- Excavation would take place every 10 years.

Because the sediment likely does not contain hazardous concentrations of mercury, the sediment could be used for building materials, landfill cover, levee maintenance or other construction projects so long as appropriate erosion control methods are employed. The above $6 per cubic yard estimate assumes that there would be a market for 50% of the sediment removed. However, depending on the market at the time excavation takes place, use of the sediment for other purposes may even entirely offset the excavation costs. In addition, excavation in the Yolo Bypass would likely increase the capacity and extend the life of the bypass.

Modifying the channel geometry to route more water down the eastern side of the Yolo Bypass could be attained by a couple of methods, including but not limited to the removal of sediment from the eastern side of the bypass to increase depth and allow more water volume to pass, or construction of a levee and a weir to divert flow towards the eastern side of the bypass. However, not enough information is available to evaluate the costs of these potential methods.

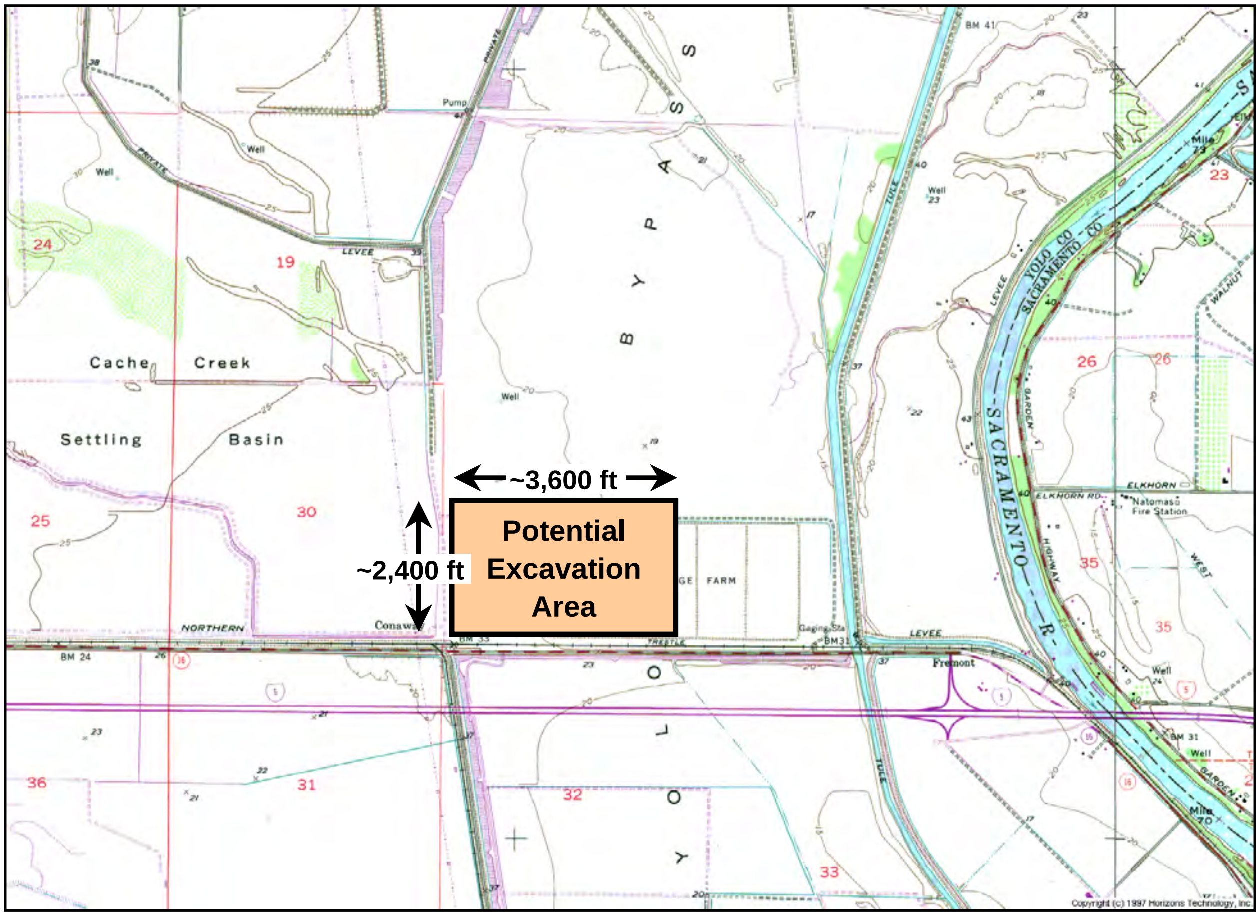


Figure C.2: Potential Excavation Area for Removing Mercury-Contaminated Sediment from the Yolo Bypass

H. NEW WATER MANAGEMENT PROJECTS

Changes in water management practices could include changes to the following:

- Operations to maintain current or future salinity standards in the Delta;
- Water deliveries to, diversions from, and storage within the Delta; and
- Dredging projects throughout the Delta and Yolo Bypass to maintain channel levees for flood conveyance, depths of deep water ship channels, and marina depths.

The proposed Basin Plan amendments require agencies that propose water management changes that could increase methylmercury or total mercury loading to the Delta do the following:

- Complete characterization studies to determine baseline conditions prior to project completion;
- Evaluate potential negative impacts of project alternatives on ambient mercury and/or methylmercury levels; and
- Develop mitigation measures for alternatives that would increase ambient mercury and/or methylmercury levels.

Potential costs associated with studies and implementation measures related to salinity standards and water deliveries and diversions are discussed below. Potential costs related to dredging and dredge disposal projects are discussed in Section H.

1. Methylmercury Characterization & Control Studies for New Projects

The proposed Basin Plan amendments require proponents for new water management projects to conduct mercury studies and develop management plans if proposed changes to water management practices and/or salinity standards have the potential to increase ambient methylmercury in the Delta. Prior to implementing a new project or management practice, responsible agencies should:

- Monitor the potentially-affected water body to characterize its baseline sulfate, methylmercury, and total mercury concentrations and loads;
- Conduct studies to evaluate the project's effects on the Delta's ambient sulfate and methylmercury concentrations, possibly including sulfate amendment studies if changes to salinity management practices are proposed; and
- If the studies indicate a project has the potential to increase methylmercury levels in the Delta, develop mitigation measures to minimize increases in ambient methylmercury.

If a proposed project has the potential to increase ambient methylmercury (e.g., by changing sulfate levels or by increasing sediment loading from a watershed with higher sediment mercury concentrations), then the responsible agencies are required to develop and implement mitigation measures to minimize to the extent practicable any methylmercury and/or total mercury loading to the Delta resulting from the new project. Responsible agencies should use feasible management practices that are not in conflict with salinity standards or other mandates (e.g., minimum flow and temperature mandates) (see Section G.2).

The required baseline characterization studies could include bi-monthly monitoring of methylmercury, total mercury, and sulfate in water at one to three sample locations in the water body for two years prior to the proposed project's implementation. The estimated cost of planning (40 hours @ $100/hr), bi-monthly monitoring labor (8 hours/sampling event with 2-person team @ $140/hr), data analyses and report writing (80 hours @ $100/hr), and sample analysis ($319/sample + 20% for field/laboratory QA samples) ranges from $30,000 to $40,000, depending on the number of locations analyzed.

Evaluating the proposed project's effects on the Delta's ambient sulfate and methylmercury concentrations would require a review of the Phase 1 characterization and control study results, published literature, and available sediment data for methylmercury and total mercury levels in the area of the Delta affected by the proposed project and the project's source waters. A careful compilation and synthesis of existing literature and water/sediment data would likely require about 80 to 160 hours of effort, which, assuming a rate of $100/hr, could cost $8,000 to $16,000. Staff assumed that it would cost four times as much to scope and model potential mitigation measures ($32,000 to $64,000).

Along with the data synthesis and modeling, laboratory experiments may be needed to evaluate how the proposed project's change to ambient sulfate levels could affect ambient methylmercury. Sulfate amendment studies should be undertaken with sediment collected throughout the year (e.g., quarterly) from areas affected by the water management change to determine whether the sulfate concentration in the overlying water affects methylmercury production in sediment and resulting ambient water column concentrations in the Delta. A potential sulfate amendment study could include collecting two *in situ* intact cores of the top 12 inches of sediment from three to six locations four times throughout the year. It could cost about $75,000 to $100,000 to conduct the field sampling and laboratory analyses, which could include analysis of the cores before and after sulfate amendment for (a) sediment total mercury, methylmercury, and sulfite/sulfate, and (b) sediment pore water methylmercury concentration gradients and high-resolution microelectrode profiling of oxygen and sulfide in the sediments.

To develop a range of potential methylmercury characterization and control study costs for new water management projects, staff assumed the following would occur during the 30 years after the effective date of the proposed Basin Plan amendments:

- Three new water management projects would take place.
- Baseline methylmercury monitoring would be required for the first new water management project to take place (1 x [$30,000 to $40,000]).
- Literature review/data evaluation ($8,000 to $16,000/project) and modeling ($32,000 to $64,000/project) would be necessary for all three projects.
- Amendment studies ($75,000 to $100,000/project) would be necessary for two projects.
- Post-project implementation monitoring – with the same assumptions used to estimate costs for the baseline monitoring – would be required for all four projects (4 x [$30,000 to $40,000]).

The resulting potential methylmercury characterization and control study costs range from $420,000 to $640,000.

2. Implementation of Methylmercury Management Practices for New Projects

Until the Phase 1 characterization and control studies are completed, and the potential effects of a new water management project are evaluated, it is not known which methylmercury management practices could be applicable. However, management practices for changes in water diversions and storage and salinity standards could include:

- Engineered controls to minimize the anoxic zone in a reservoir (e.g., aeration);
- Alternate locations for water storage reservoirs (i.e., is the proposed project in a mercury contaminated watershed?);
- Alternative discharge patterns (volume, frequency, season);
- Modification of discharge from top or bottom of reservoir; and
- Reduction of upstream sources of total mercury (e.g., additional settling basins on select watersheds, reducing erosion of mercury-contaminated stream banks, and mine and dredge field remediation).

Installation costs for a reservoir aeration system range from $210,000 to $250,000 for a water body with a surface area of 100 acres (S. Walker, 2007; Clean-Flo, 2007). Yearly operations and maintenance costs include electricity for the operation of the aeration pumps and other general maintenance costs. A reservoir aeration system uses approximately 22,850 kilowatt-hours/month for a reservoir with a surface area of 1,600 acres (Fast, 1968). The electricity for solar-powered aeration units is completely supplied by solar panels and therefore these units have no electricity costs. Current electricity rates for the Sacramento Municipal Utilities District (SMUD) are $0.1683/Kwatt-hour for the summer season (May - October) and $0.1537/Kwatt-hour for the winter season (November - April). The total annual electricity cost for continuous year-round usage of an aeration system that is not solar powered is about $2,800 for a 100-acre water body. A more likely usage period would be the summer season; the annual electricity cost for continuous six-month usage could be about $1,400. Other general maintenance costs are $1,500/yr to $3,000/yr for a 100-acre water body (Fast, 1968; S. Walker, 2007). Assuming a 30-year project life, the total annual costs for the installation, operation and maintenance of a reservoir aeration system range from about $8,500/yr to $12,700/yr for a 100-acre water body.

Constructing additional settling basins on select watersheds that supply mercury-enriched sediment to the Delta is another potential methylmercury management practice. Staff estimated costs for the construction and maintenance of a ten-acre settling basin. Assuming that the levee is a half-mile long (a square 10–acre basin would be 660 x 660 ft with a perimeter of about 0.5 mile), 50 feet wide and 20 feet high, and that the earthwork costs are $5.50 per cubic yard of material (LWA, 2005), the approximate levee earthwork cost is about $540,000. As noted in Section A.1, CDM (2007) estimated that enlarging the Cache Creek Settling Basin by 1,500 acres would cost about $14.7 million. Assuming no economy of scale, the CDM cost estimate scales down to about $98,000 for a 10-acre basin. Staff expects that basin construction costs could range between $98,000 and $540,000. The construction of a settling basin could include additional costs for easement fees, permits, environmental analysis, and administrative costs, which could range from about $60,000 to $120,000. The total initial cost for the construction of a settling basin could range from about $158,000 to $660,000 (about $5,300/yr to $22,000/yr when averaged over a 30-year period).

Annual maintenance costs for a settling basin includes levee maintenance costs and yearly sediment removal. The total annual maintenance cost for the settling basin ranges from about $25,000/yr to $45,000/yr, assuming that (a) the annual cost to maintain a levee is $11,000 per mile (LWA, 2005), (b) the 10-acre basin was excavated by 2 feet (32,300 cubic yards of material removed) every ten years, and (c) the cost for sediment excavation is about $6 to $12 per cubic yard, if zero to 50% of the excavated material were sold for use as fill in other projects in the region. Assuming a project life of 30 years, the annual cost for the construction and maintenance of a 10-acre settling basin could range from about $30,000/yr to $67,000/yr.

Reducing erosion from mercury-contaminated stream banks is another management practice to reduce total mercury loads to the Delta. An estimated cost for stream bank stabilization is $150 per foot (NRCS, 2000). If one mile (5,280 feet) of contaminated stream bank were stabilized, the approximate project cost would be $792,000. Assuming a 30-year project life, the annual cost for stream bank stabilization along a one-mile reach is about $26,400/yr. LWA (2005) estimated that it would cost $70,600/yr to stabilize sediment along both banks of a 12,000-foot reach of the Sulphur Creek floodplain for a 30-year project life, or about $15,500/yr/mile along one bank.

Mine and dredge field remediation also could reduce total mercury loads to the Delta. Possible dredge field remediation activities could include stream bank stabilization or excavation of contaminated sediment. The costs of these activities are discussed previously. The costs for mine remediation vary with factors such as, but not limited to, area affected by the mine, type of mine, mine topography, mine location etc., thus the range of possible remediation actions is large. Cost estimates for the cleanup of the Abbott-Turkey Run mine site ranged from $6.5 million to $6.7 million for a 30-year project life (Tetra Tech, 2003; LWA, 2005). The USGS (Wood, 2003) reported the estimated costs for several different mines at $800,000 to $10.8 million each including O&M costs. Assuming a 30-year project life, the cost for initial mine remediation and annual O&M could be about $27,000/yr to $360,000/yr per mine.

Additional methylmercury control options that involve alternate locations for water storage reservoirs, alternative project discharge patterns, and modification of discharge from top or bottom of reservoirs are highly project- and watershed-specific, and should be evaluated during the project design stage.

To develop a range of potential methylmercury management implementation costs for new water management projects, staff made the following assumptions:

- Three water management projects would take place that would require the implementation of methylmercury management practices.
- One project would implement an aeration system, assumed to have a surface area of 500 acres ($42,500/yr to $63,500/yr).
- One project would construct and maintain a new settling basin upstream of its affected area ($30,000/yr to $67,000/yr).
- One project would stabilize a three-mile reach of stream bank upstream of its affected area ($46,600/yr to $79,200/yr).

Given these assumptions, the resulting total potential cost to new water management projects to implement methylmercury management practices could range from about $120,000/yr to $210,000/yr.

I. DREDGING OPERATIONS & DREDGE MATERIAL REUSE

1. Characterization of Methyl and Total Mercury at New Project Sites, DMD Sites, and Dredge Material Reuse Sites

The proposed Basin Plan amendments require project proponents for future dredging activities and dredge material disposal activities in the Delta/Yolo Bypass to minimize potential increases in ambient methylmercury in the Delta/Yolo Bypass waterways. Currently, the U.S. Army Corps of Engineers does routine maintenance dredging in the Ports of Stockton and Sacramento and in the Stockton and Sacramento Deep Water Ship Channels. These maintenance projects are the most frequent and extensive in the Delta area (Table 6.17 in the Delta TMDL), and they account for approximately 88% of all the annual dredging activity in the Delta. The other 12% of the annual Delta dredging activity is comprised of small marinas and bays. Recent WDRs include requirements for dredge projects to conduct chemical and physical testing of sediments that are representative of the area to be dredged before each maintenance project, as well as of dredge material disposal (DMD) site return flows to receiving waters.

To determine whether a dredge project increases *in situ* methylmercury production, project proponents should conduct pre-project sediment sampling. Currently, the USACE performs analyses of sediments to be dredged to determine the anticipated sediment quality during dredging operations. The USACE removes and analyzes core samples in the project area before dredging occurs. The average number of core samples per project site ranges from 13 in the Sacramento Deep Water Ship Channel to 34 in the Stockton DWSC (J. Headlee, 2007). These core samples are analyzed for total mercury; however, various horizons from the core are composited for the analysis (J. Headlee, 2007). In order to characterize the concentrations of total mercury in the pre- and post-project surface sediments, the USACE would need to collect discrete samples at the existing sediment surface, proposed “new surface” sediment horizon, and one foot below the proposed horizon. The layer (depth) specific core analyses could be done with the core samples the USACE already takes.

Costs for additional methyl and total mercury characterization of USACE’s typical annual Delta dredging projects could cost about $15,000/yr, based on analysis costs listed in Table C.1 and the following assumptions:

- <u>Sampling frequency</u>: one pre-dredging sampling event for each annual maintenance-dredging project (e.g., one project on the Sacramento DWSC and one project on the Stockton DWSC).
- <u>Sampling strategy</u>: (a) collect discrete samples at the existing sediment surface, proposed “new surface” sediment horizon, and one foot below the proposed horizon for total mercury analysis, and (b) discrete samples at the existing sediment surface for methylmercury.
- <u>Labor – sediment sampling</u>: additional labor costs for slicing and dissection of core sample to obtain discrete samples for total mercury analysis ($100/core sample) and methylmercury analysis ($50/ core sample) (J. Headlee, 2007).
- <u>Labor – administrative</u>: $800 per year per project (2 projects x 8 hours x $100/hr).

- Number of sediment samples per project site: 45 samples for total mercury analysis, and 15 samples for methylmercury analysis, assuming that 5 cores are collected from the Sacramento DWSC and 10 cores are collected from the Stockton DWSC. Analysis costs would include an additional 20% for field and laboratory QA samples.

Assuming the costs are proportional to the size of the dredging projects, the additional costs for the remaining Delta dredging projects could be about $2,000/yr.[10]

In the study scenario outlined above, staff assumed that the dredged material would be placed at a DMD site where the associated pore water in the material is not discharged to surface waters. However, at some DMD sites, the pore water from the dredge material is returned to surface waters. During some years there is no discharge from DMD sites, while during other years four or more projects may have DMD sites that discharge to surface waters. To determine whether DMD return water would increase ambient methylmercury in receiving waters, project proponents should monitor methylmercury in DMD return water and receiving water. If monitoring indicates that DMD return flows have methylmercury concentrations greater than the receiving water concentration, the return flow could be held in settling ponds or other diked disposal sites on land for a longer hold time until methylmercury concentrations decrease (e.g., through photodegradation). Similar practices already are required to comply with the CTR criterion of 50 ng/l for total recoverable mercury in the water column and water quality objectives for turbidity already established in the Basin Plan. Alternatively, the return flow could be disposed to land with no discharge to surface water. Typically, the return water from a DMD site is discharged for a duration of about two weeks. DMD discharge and receiving water monitoring could cost about $6,000/yr, based on analysis costs listed in Table C.1 and the following assumptions:

- Sampling frequency: DMD site operators could monitor the return flow and receiving water for methylmercury three times during the two-week period of discharge ((2 samples x 3 sampling events x $166/sample) x 1.2 [to account for QA/QC samples] = $1,195).
- Sampling labor: Staff assumed that a two-person sampling team could monitor the return flow and receiving water at one DMD site in three hours at $140/hr (3 hours/event x $140/hr x 3 sampling events = $1,260).
- Administrative labor: $500 per dredging project (five hours at $100/hr), including sampling plan development, data analysis, and report writing.
- Number of Projects: Staff assumed that two separate projects a year would result in DMD site discharge to receiving waters.

Dredge material could be used as fill for wetland and riparian habitat restoration projects. The first step in ensuring that the reuse of dredge material at such aquatic locations does not increase the bioavailability of mercury at the sites is baseline monitoring then additional monitoring after the restoration project is completed. Pre- and post-restoration monitoring could cost about $86,000, based on analysis costs listed in Table C.1 and the following assumptions:

- Quarterly surface sediment sampling would take place for one year before the proposed project and two years after the proposed project, for a total of 12 sampling events.

[10] The USACE dredge operations account for approximately 88% of the 533,400 yd^3 of sediment dredged annually from the Delta (Table 6.17 in the TMDL Report).

- Four sites would be sampled per restoration project. At each site, three samples would be collected and analyzed per sampling event. Staff assumed that a two-person sampling team could sample four sites in one 8-hour day at $140/hr.
- The following sediment analyses would be performed for each sample: inorganic mercury concentration, methylmercury concentration, and moisture content/density. Analysis costs would include an additional 20% for field and laboratory QA samples.
- Study design, data analyses, report writing, and administration would entail 120 hours per project at $100/hr.

To develop a range of potential methylmercury characterization costs for projects that reuse dredge material in an aquatic environment, staff assumed that five such projects would occur during the 30 years after the effective date of the proposed Basin Plan amendments. The resulting characterization cost is about $430,000 (or about $14,000/yr when averaged over 30 years).

2. Implementation of Methylmercury and/or Total Mercury Management Practices for New Projects As Needed

Dredging the bottom of channels and marinas in the Delta potentially could expose new sediments that contain higher concentrations of total mercury and result in increased methylmercury production in and flux from the sediment to the overlying water column. If the pre-project sediment core sampling described in the previous section determines that the sediment that would be exposed by the project has an average total mercury concentration greater than the surface material before dredging, then the project proponent needs to take action to ensure that the project does not cause long-term increases in methylmercury production. Reasonably foreseeable methods of compliance could include dredging deeper until a horizon with lower mercury levels is exposed, or continuing with the project as proposed, but conduct monthly post-project monitoring for at least four months to ensure that natural sedimentation covers the exposed surface with ambient sediment.

In a typical year of maintenance dredging in the Stockton DWSC, the USACE removes sediment from a reach that is on average about 15,600 feet (three miles) long and about 300 feet wide, with an average project area of 4.68 million square feet (J. Headlee, 2007). It is likely that just a portion (e.g., 20%) of the reach would have a sediment lens with relatively high mercury concentration, rather than the entire reach. If the USACE chose to dredge that portion of the project area (e.g., about 936,000 square feet) one foot deeper to expose a layer of sediment with a lower average mercury concentration, then about 35,000 cubic yards of additional sediment would need to be removed. Dredging costs about $10 per cubic yard of sediment removed (J. Headlee, 2007). Therefore, the estimated cost for dredging 20% of a typical project area one foot deeper is $350,000.

Another methylmercury management option for the USACE should pre-project core sampling indicate that a mercury-enriched sediment lens would be exposed by dredging could be to continue with the project as proposed, but monitor the project site for four months after dredging activities are completed to ensure that the exposed surface is covered by natural sedimentation with sediment with lower mercury levels. Post-dredging sediment monitoring could cost about $15,000 based on analysis costs listed in Table C.1 and the following assumptions:

- Surface sediment is sampled monthly at four sites in the mercury-enriched area for four months. Staff assumed that a two-person sampling team could sample four sites per 8-hour day at $140/hr.
- Each sediment sample would be analyzed for total and methyl mercury. Analysis costs would include an additional 20% for field and laboratory QA samples.
- Study design, data analyses, report writing, and administration would entail 40 hours per mercury-enriched area at $100/hr.

If the newly exposed surface is not covered with ambient sediment containing lower total mercury levels than the original sediment within four months, and the methylmercury concentrations of the exposed surface are higher than the original surface sediment's methylmercury concentration, the responsible parties could perform the additional dredging activities mentioned above.

Both the Stockton and Sacramento Deep Water Ship Channels are maintained for approximately 45 miles each. Because three miles is the typical channel length dredged per year in each channel, it would take approximately 15 years to complete the maintenance dredging for the entire length of each channel. To estimate potential costs for dredging projects, staff assumed the following:

- Dredging activities would expose a mercury-enriched sediment lens once in any given five-year period, averaging six such exposures in a 30-year period.
- Four of the exposures would be adequately covered by natural sedimentation and therefore entail only monitoring costs [4 x $15,000 = $60,000].
- Two of the exposures would be addressed by dredging an additional foot [2 x $350,000 = $700,000].

When considered over a 30-year period, the resulting potential costs average about $25,000/yr.

As noted in the previous section, dredge material could be used as fill for wetland and riparian habitat restoration projects. If pre- and post-restoration monitoring indicated that there was an increase in surface sediment methylmercury concentration that could not be explained by pre-project variability, then during Phase 2 (after the completion of the methylmercury characterization and control studies), the managers for the new wetlands constructed during Phase 1 could implement management practices to reduce methylation to the extent practicable, using methods like those described in Section D.3.

J. TRIBUTARY WATERSHEDS

1. Watershed Methyl and Total Mercury Source Analyses and Control Feasibility Studies in Coordination with Upstream TMDL Development Efforts

The Central Valley Water Board conducted a three-year study to determine mass loading, riverine characterization, and exports of methyl and total mercury and suspended sediment of the Central Valley watershed, including the Sacramento River, San Joaquin River, Yolo Bypass, Delta, major tributaries, and many sub-watersheds. The cost of the study including planning, sampling, chemical analysis, data analyses and report writing was $600,000/yr (SJSU, 2005). The estimated cost of a source analysis study for individual watersheds could cost from $50,000/yr for smaller watersheds to $200,000/yr for larger watersheds.

Source analyses already are required for watersheds with 303(d) Listed mercury-impaired waterways, and therefore such analyses are not considered new costs resulting from the proposed Basin Plan amendments. Watersheds with 303(d)-Listed mercury-impaired waterways downstream of major dams include the American River, Feather River, Marsh Creek, Merced River, Putah Creek, Sacramento River, San Joaquin River, and Stanislaus River. The proposed Basin Plan amendments include methylmercury allocations that require methylmercury load reductions for exports from the following watersheds that are not currently 303(d)-Listed as mercury-impaired: Mokelumne River, Cosumnes River, Morrison Creek, French Camp Slough, Knights Landing Ridge Cut (Colusa Basin Drain), Cache Slough/Lindsey Slough, Ulatis Creek, and Willow Slough. However, in-progress data evaluations for the 2008 303(d) Listing cycle indicate that, based on recently-collected fish mercury data, the Mokelumne River likely will become 303(d)-listed as mercury-impaired (D. Bosworth, 2007, pers. comm.) and therefore will require a TMDL source analysis. It could cost about $450,000 to conduct a source analysis study for the seven watersheds not currently or expected to be 303(d)-Listed, given the following assumptions:

- Cosumnes River and Colusa Basin Drain ($100,000/watershed):
  - Sampling locations per watershed: 16.
  - Number of sampling events: 10 (bi-monthly sampling plus 4 storm sampling events).
  - Water analyses: unfiltered methyl and total mercury and SSC, plus 20% for field and laboratory QA samples.
  - Field labor: 8 sites per 8-hour day at $140/hr.
  - Data analysis, report writing & administration: 160 hours/watershed at $100/hr.
- Five smaller watersheds ($50,000/watershed):
  - Sampling locations per watershed: 8.
  - Number of sampling events: 10 (bi-monthly sampling plus 4 storm sampling events).
  - Water analyses: unfiltered methyl and total mercury and SSC, plus 20% for field and laboratory QA samples.
  - Field labor: 8 sites per 8-hour day at $140/hr.
  - Data analysis, report writing & administration: 80 hours/watershed at $100/hr.

The Central Valley Water Board has contracted with an environmental engineering consultant to identify and evaluate a suite of potential inorganic mercury reduction projects in the Central Valley. The approximate cost to conduct this control feasibility study is $150,000. Particular options that may be explored further as part of this study include:

- Determination of potential sites for new settling basins below mercury-contaminated watersheds;
- Identification of dredge tailings for which remediation may be feasible;
- Identification of mine sites and/or streambeds with contaminated material for which stabilization or other remediation actions may be feasible; and
- Determination of projects that could be implemented to more immediately reduce mercury levels in the Yolo Bypass.

Those projects identified as reasonable will be evaluated in detail for implementability (long-term operation and maintenance, regulatory acceptance, scheduling constraints), effectiveness (short and long-term effectiveness, impacts of the alternative on humans and the environment, and community acceptance), and cost (capital and operations and maintenance). Additional watershed total mercury source analyses and control feasibility studies likely will be needed to fulfill the proposed Basin Plan amendments' requirement for a total mercury load reduction of 110 kg/yr as well as requirements associated with upstream TMDL implementation programs. Additional control feasibility studies likely would cost $500,000 to $1 million. Assuming that more than half of these studies would be directly associated with upstream TMDL implementation efforts, costs incurred by studies to fulfill Delta-specific requirements likely would range from $250,000 to $500,000.

2. Total Mercury Loading Study for Suisun and San Francisco Bays and the Central Valley

The proposed Basin Plan amendments note that that the Central Valley and San Francisco Bay Water Boards should conduct coordinated studies to evaluate the mercury and methylmercury loads between the two regions. As mentioned in the previous section, the Central Valley Board conducted a mass loading study, which included Central Valley watershed exports to the San Francisco Bay. This three-year study consisted of monthly sampling at Chipps Island/Mallard Island, where the Delta exports to the Bay. Possible follow-up studies could sample multiple locations down the Bay-Delta to characterize the total mercury and methylmercury flux between the regions. It could cost about $180,000 to conduct a two-year study, given an annual expense of $90,000/yr based on the following assumptions:

- Sampling locations: 4.
- Number of sampling events: 30 (26 bi-weekly plus 4 storm sampling events).
- Water analyses: unfiltered methyl and total mercury and SSC, plus 20% for field and laboratory QA samples.
- Field labor: 4 sampling locations per 8-hour day at $140/hr using a watercraft.
- Data analysis, report writing & administration: 80 hours at $100/hr.

3. Implementation of High Priority, Cost-effective Total Mercury Reduction Projects

Possible control actions to reduce total mercury loads to the Delta include, but are not limited to: construction of additional settling basins on select watersheds, reducing erosion from mercury-contaminated stream banks, mine and dredge field remediation. Potential costs associated with these types of actions are discussed in Section G.2.

Total mercury control project costs are highly project- and watershed-specific with great variability from one project to the next. Until the feasibility control studies described in Section J.1 have been completed, overall costs associated with total mercury control actions are very speculative. In addition, implementation of other upstream TMDLs will require total mercury control actions that may achieve the total mercury reduction requirements of the Delta and San Francisco TMDL implementation plans. Also, as noted in Section 4.3.11, the Porter Cologne Water Quality Control Act gives the Regional Water Boards the authority to require responsible persons to cleanup and abate wastes that cause or threaten to cause pollution; mine sites that discharge wastes may be subject to waste discharge requirements (Title 27 requirements for mine wastes and/or NPDES storm water requirements for industrial facilities). Even in the absence of a Delta mercury control program, mine owners are responsible for discharges from their property. In this context, the Delta mercury control program will not pose new economic costs to address discharges from mercury and gold mines.

Total mercury control actions beyond those needed for upstream TMDL, Title 27, or NPDES requirements could conceivably cost about $250,000/yr to $470,000/yr to implement and maintain during their first 30 years, based on the following assumptions:

- Three new 10-acre settling basins would be constructed (3 x [$30,000/yr to $67,000/yr])
- Ten miles of stream banks with mercury-contaminated sediment would be stabilized (10 x [$15,500/yr to $26,400/yr]).

4. Phase 2 Implementation of Methylmercury Management Practices in the Delta's Tributary Watersheds

Identified sources of methyl and total mercury in the Delta's tributary watersheds include geothermal springs, methylmercury flux from sediments in wetlands and open water habitats, municipal and industrial dischargers, agricultural drainage, urban runoff, atmospheric deposition, and erosion of naturally mercury-enriched soils and excavated overburden and tailings from historic gold and mercury mining operations. Reasonably foreseeable methods of compliance with the methylmercury allocations for tributary inputs to the Delta and Yolo Bypass could include any or all of the methods outlined in previous sections for WWTPs, MS4s, irrigated agriculture, wetlands, and open water methylmercury sources. In addition, another reasonably foreseeable method would be to focus total mercury reduction efforts on sources that supply mercury to hotspots of methylation in the tributary watersheds. Total mercury actions associated with this method are described in the previous section and in Section G.2.

Several upstream waterways are also on the CWA 303(d) List as impaired by mercury and are scheduled for TMDL development during Phase 1 of the Delta TMDL implementation plan. The watersheds with 303(d) Listed mercury-impaired waterways downstream of major dams include: American River, Feather River, Marsh Creek, Merced River, Putah Creek, Sacramento River, San Joaquin River, and Stanislaus River. In addition, the Mokelumne River also is likely to be listed during the 2008 303(d) Listing cycle (D. Bosworth, 2007, pers. comm.). Staff assumed that methylmercury and total mercury control actions taken to achieve upstream TMDL requirements for those requirements would be adequate to achieve Delta TMDL tributary input allocations.

The proposed Basin Plan amendments include methylmercury allocations that require methylmercury load reductions for exports from the following watersheds that are not currently 303(d)-Listed or expected to be listed during the 2008 cycle as mercury-impaired: Cosumnes River, Morrison Creek, French Camp Slough, Cache Slough/Lindsey Slough, Knights Landing Ridge Cut (Colusa Basin Drain), Ulatis Creek, and Willow Slough. Staff reviewed readily available NPDES, land use, and mining information to estimate potential costs to reduce methylmercury exports from these watersheds.

Table C.15 lists the NPDES-permitted facilities that discharge to these watersheds. Seven of the ten municipal WWTPs discharge effluent with methylmercury concentrations greater than 0.06 ng/l: Canada Cove LP French Camp Golf & RV Park, Davis WWTP, Galt WWTP, Jackson WWTP, Maxwell PUD WWTP, Williams WWTP, and Colusa WWTP. Only two of these WWTPs discharge greater than 1 mgd. No effluent methylmercury data are yet available for the Willows WWTP. With one exception, the rest of the facilities listed in Table C.15 either have effluent methylmercury concentrations less than 0.06 ng/l or are power or groundwater treatment facilities, which, as noted in Section 4.3, are not expected to act as measurable sources of methylmercury. No effluent methylmercury data are yet available for the SPI Martell Complex/Sierra Pine facility; effluent concentration results collected at the SPI Anderson and Shasta Lake facilities ranged between 0.023 and 1.19 ng/l (Bosworth *et al.*, 2008).

Table C.16 summarizes the watershed land uses. The Cosumnes River, French Camp Slough, Cache/Lindsey Slough, Colusa Basin Drain, Ulatis Creek, and Willow Slough watersheds are mostly comprised of agriculture and open space. Morrison Creek is comprised of agriculture and urban land uses; there is more urban land in the Morrison Creek watershed (about 44,000 acres) and Cosumnes River watershed (about 36,000 acres) than there is in the entire Delta/Yolo Bypass (about 60,000 acres).

A review of available mine feature GIS databases (CDMG, 1998; OMR, 2000 & 2001; USGS, 2005) indicates the following:

- The Morrison Creek watershed upstream of Mather Lake intersects the southern edge of the historic Folsom gold district dredge field tailings. Sand, gravel, and clay mining takes place elsewhere in the watershed.
- The Cosumnes River watershed has about 800 named historic gold mines, about 1,400 identified gold mining features, and one mercury mine. There are both placer and lode (hard rock) mining features.
- The French Camp Slough watershed has about 50 named historic gold mines, about 80 historic gold mine features, and several mining features related to recent and historic gravel, clay, and copper mining. All but a couple of the gold mine features are in the uppermost watershed, upstream of the Farmington Flood Control Basin.

- The Ulatis Creek and Willow Slough watersheds have clay, sand, gravel, and stone mining.
- The Cache/Lindsey Slough watershed has no mining features of any kind.

Phase 1 methylmercury characterization/control studies, methylmercury and total mercury watershed sampling, and engineering feasibility studies for total mercury control projects need to be completed to determine which types of management practices will most effectively reduce methylmercury discharges from the tributary watersheds. To estimate potential overall costs to reduce methylmercury exports from the watersheds not currently or expected to be 303(d)-Listed, staff assumed the following based on available information about possible controls and management practices:

- Cosumnes River and French Camp Slough mine site cleanups, bank stabilization, and settling basin construction:
  - The cost for stream bank stabilization costs about $15,500 to $26,400/yr/mile (see Sections H.2 and J.3). Stabilizing 3 miles of mercury-contaminated stream banks downstream of major mining areas could cost about $47,000/yr to $79,000/yr. This potential cost is incorporated in the potential high-priority total mercury reduction project costs described in Section J.3.
  - The annual cost for the construction and maintenance of a 10-acre settling basin could range from about $30,000/yr to $67,000/yr (see Section H.2). This potential cost is incorporated in the potential high-priority total mercury reduction project costs described in Section J.3.
  - The annualized cost for initial mine remediation and O&M could be about $27,000/yr to $360,000/yr per mine (see Section H.2). As noted earlier, the Porter Cologne Water Quality Control Act gives the Regional Water Boards the authority to require responsible persons to cleanup and abate wastes that cause or threaten to cause pollution; mine sites that discharge wastes may be subject to waste discharge requirements (Title 27 requirements for mine wastes and/or NPDES storm water requirements for industrial facilities). Even in the absence of a Delta mercury control program, mine owners are responsible for discharges from their property. In this context, the Delta mercury control program and any resulting control program for the Cosumnes and French Camp watersheds will not pose new economic costs to address discharges from mercury and gold mines.
- Morrison Creek study and dredge tailing stabilization:
  - A study to evaluate how much mercury-contaminated sediment is transported from the dredge field downstream of Mather Lake would cost about $15,000. [This potential cost is included on Table 4.4 with the "Tributary Watershed: watershed MeHg source analyses" costs, <u>in addition</u> to the costs described in Section J.1.]
  - Stabilizing a ½ mile segment of stream (both banks) through the dredge field could cost about $15,500/yr to $26,400/yr. This potential cost is incorporated in the potential high-priority total mercury reduction project costs described in Section J.3.

- NPDES-permitted facilities ($210,000/yr to $230,000/yr, sum of potential costs for all affected facilities):
  - The facility that currently performs filtration, Canada Cove LP WWTP, could conceivably add ultraviolet radiation (0.04 mgd x $36,000/mgd = $1,400/yr).
  - The Jackson WWTP could implement a total mercury minimization program to decrease its total mercury discharges, which would likely decrease its methylmercury discharges ($200,000/year; see Section C.4 for cost assumptions).
  - The Davis and Galt WWTPs would be required by Implementation Alternative #3 to implement total mercury minimization programs, which are expected to reduce their methylmercury discharges.
  - The Davis WWTP is expected to begin tertiary treatment, which likely would enable further reductions in its methylmercury discharges.
  - The rest of the municipal WWTPs that discharge effluent with methylmercury concentrations greater than 0.06 ng/l, as well as the Willows WWTP, are expected to begin tertiary treatments, which staff assumed would enable reductions in their methylmercury discharges.
  - The SPI Martell Complex/Sierra Pine complex, which produces wastewater from a particleboard manufacturing facility and a wood-burning cogeneration facility, could be required to characterize its current waste streams and discharges to Stony Creek, a tributary to the Mokelumne River, and implement pollution prevention measures to reduce total mercury discharges. For the first year of monitoring, it would cost about $15,000 to conduct six sampling events (four quarterly and two storm events) at five monitoring locations and to analyze the samples for methylmercury, total mercury and SSC ($377/sample (including 20% for QA/QC) plus field labor). Monitoring during following years could be limited to two monitoring locations sampled four times a year ($3,000/year). Averaged over 30 years, monitoring would cost about $3,400/year. Costs for pollution prevention measures to reduce total mercury discharges could cost about $5,000 to $20,000/yr, depending on the sources of mercury to the waste stream and stormwater runoff and equipment and chemicals used at the complex.[11] Overall annual costs would be about $8,000 to $23,000/yr.
- NPDES-permitted MS4s ($82,000/yr to $170,000/yr, sum of potential costs for all affected MS4s):
  - In addition to implementing mercury control plans as described in Section C.3, the large MS4s (Sacramento and Stockton Area MS4s) could implement control actions at 15 locations in the Cosumnes River, Morrison Creek, and French Camp Slough watersheds, which could cost $800/yr to $1,500/yr at 10 locations [$8,000/yr to $15,000/yr], $1,500/yr to $5,000/yr at 3 locations [$4,500/yr to $15,000/yr], and

[11] Mercury is potentially used or released at paper mills in four different areas: (1) a component in equipment (e.g., switches, gauges, thermometers, batteries, lamps); (2) an ingredient in detergents or laboratory chemicals (e.g., thimerosal); (3) a contaminant in raw materials (e.g., caustic soda and sulfuric acid); and (4) an incidental release due to a production process (e.g., coal or wood combustion, and power-plant cooling water treated with pH-altering chemicals such as caustic soda and sulfuric acid) (Huber, 1997). Pollution prevention measures to reduce total mercury discharges could include identifying and labeling instruments and chemicals that contain mercury; implementing effective maintenance, disposal, recycling, and spill response plans; finding alternative instruments and chemicals that do not contain mercury; and switching to low-mercury feedstock chemicals (e.g. caustic soda and sulfuric acid with lower mercury levels).

$5,000/yr to $10,000/yr at 2 locations [$10,000/yr to $20,000/yr], for a total of $22,500/yr to $50,000/yr.

  - The small MS4s (Table C.17) in the Cosumnes River, French Camp Slough, Cache Slough/Lindsey Slough, Colusa Basin Drain, Ulatis Creek, and Willow Slough watersheds likely could reduce their methylmercury discharges by implementing pollution prevention measures for total mercury, coordinated with other MS4s and WWTPs in their regions [12 communities x ($5,000/yr to $10,000/yr) = $60,000/yr to $120,000/yr].

- Agriculture ($370,000/yr to $830,000/yr sum of potential costs for all affected agricultural areas), based on the review of DWR Land Use data, assumptions in Section F.3, and the following assumptions:
  - Of the approximately 1.2 million acres of agriculture land in the seven non-303(d) Listed watersheds, approximately 130,000 acres are irrigated with flood irrigation. According to the USDA Farm and Ranch Survey (2004), approximately 16% of flood-irrigated lands utilize tailwater recovery systems in California; hence, approximately 84% (110,000 acres) of flood-irrigated agricultural lands may not currently use tailwater recovery systems but possibly could. Installation costs for tailwater recovery systems range from $481 to $550 per acre; annual costs for operation and maintenance is $12 to $13 per acre (Schwankl, 2007; see Section F.2). If about 10% to 20% of agricultural lands that are currently using flood irrigation but not using tailwater recovery systems installed tailwater recovery systems (about 11,000 to 22,000 acres), it would cost about $5.3 million to $12 million for installation and about $130,000/yr to $290,000/yr to maintain the systems (about $300,000/yr to $680,000/yr when averaged over a 30-year period).
  - Of the approximately 490,000 acres of orchards and vineyards, 3,200 acres are irrigated by flood irrigation (DWR, 1994-2006). The cost differential for a micro-irrigation system compared to flood irrigation, the baseline condition, is $227 per acre/yr (see Section F.3). If about 10% to 20% all of the orchards and vineyards using flood irrigation (about 320 to 640 acres) converted to micro-irrigation, the annual cost could range from about $73,000/yr to $150,000/yr.

Once the Phase 1 methylmercury characterization and control studies, watershed source analyses for methyl and total mercury, and feasibility control studies for total mercury are completed, then the overall costs associated with methylmercury control actions in the upstream watersheds will be further evaluated.

Table C.15: Non-303(d)-Listed Watersheds Required by the Proposed Basin Plan Amendments to Reduce Their Methylmercury Exports to the Delta/Yolo Bypass – *NPDES-permitted Facilities*.

Agency (NPDES No.)	**Type of Facility**	**Flow** (mgd)	**Effluent MeHg Conc.** (ng/l) [(a)]
Cosumnes River Watershed			
El Dorado Irrigation District (EID) Deer Creek WWTP (CA0078662)	Mun WWTP	2.52	0.015
EID El Dorado Hills WWTP (CA0078671)	Mun WWTP	1.08	0.013
Galt WWTP (CA0081434)	Mun WWTP	1.92	0.139
Jackson WWTP (CA0079391)	Mun WWTP	0.71	0.108
SMUD Rancho Seco Nuclear Generating Station (CA0004758)	Power	0.09	0.04
SPI Martell Complex/Sierra Pine (CA0004219)	Paper Mill	0.57	na [(b)]
Colusa Basin Drain Watershed			
Colusa WWTP (CA0078999)	Mun WWTP	0.66	2.863
Maxwell PUD WWTF (CA0079987)	Mun WWTP	0.14	0.993
Williams WWTP (CA0077933)	Mun WWTP	0.30	1.553
Willows WWTP (CA0078034)	Mun WWTP	0.89	na
French Camp Slough Watershed			
Canada Cove LP French Camp Golf & RV Park (CA0083682)	Mun WWTP	0.04	0.147
Defense Logistics Agency Sharpe GW Cleanup (CA0081931)	WTP (GW)	1.90	0.018
Morrison Creek Watershed			
AFB Conversion Agency A C & W GW Treatment (CA0083992)	WTP (GW)	0.39	na
Boeing Company Interim Treatment System (CA0084891)	WTP (GW)	1.44	<0.02
Pacific Coast Sprout Farms, Inc. (Sacramento Facility) (CA0082961)	Aquaculture	0.1	<0.02
Proctor & Gamble Co. WWTP (CA0004316)	Manufacturing	5.50	<0.02
Sacramento Cogen Authority Procter & Gamble Plant (CA0083569)	Power	na	0.052
Sacramento Power Authority Campbells Cogen Plant (CA0083658)	Power	0.60	*No recent discharge.*
Ulatis Creek Watershed			
Collins and Aikman Former Wickes Forest Industries (CA0081531)	WTP (GW)	0.022	na
Kinder Morgan Elmira Remediation Project (CA0084719)	WTP (GW)	0.07	na
Kinder Morgan Fox Rd Pipeline Release Site (CA0084760)	WTP (GW)	0.072	na
Vacaville Easterly WWTP (CA0077691)	Mun WWTP	9.26	0.024
Willow Slough Watershed			
Davis WWTP (CA0079049)	Mun WWTP	5.26	0.574

(a) Methylmercury concentration data for municipal WWTPs that discharge greater than 1 mgd are provided in Appendix L. All other facilities' data are provided in *A Review of Methylmercury Discharges from NPDES Facilities in California's Central Valley* (Bosworth *et al*., 2008).

(b) Methylmercury concentration data for were not available for the SPI. However, effluent concentration results collected at the SPI Anderson and Shasta Lake facilities ranged between 0.023 and 1.19 ng/l.

Table C.16: Non-303(d)-Listed Watersheds Required by the Proposed Basin Plan Amendments to Reduce Their Methylmercury Exports to the Delta/Yolo Bypass – *Land Uses*.

LANDCOVER	Cosumnes River	Colusa Basin	French Camp Slough	Morrison Creek	Ulatis Creek	Upper Lindsay/ Cache Slough	Willow Slough
Agriculture	***234,632***	***694,567***	***102,414***	***59,132***	***43,325***	***16,120***	***80,363***
Agriculture (Other, mixed, or uncategorized)	6,000	22,803	4,313	1,868	1,853	985	2,938
Crop & Pasture	154,862	99,434	5,273	38,366	6	2	11,097
Orchard	2,591	76,264	9,172	162	4,328		5,412
Orchard & Vineyard	1,196	2,307		226	0		501
Pasture	22,554	46,283	20,558	9,848	9,377	1,589	12,191
Rice Fields	182	216,034	6,881				3,445
Row and Field Crops	23,195	225,043	46,090	7,797	27,716	13,544	44,727
Vineyard	24,051	6,400	10,127	863	45		52
Barren	***3,008***	***2,828***		***3,078***			***4***
Barren		2,256					
Sandy Area (non-beach)		253					1
Strip Mine or Quarry	3,008	318		3,078			3
Open Recreation	***2,507***	***7,975***	***1,486***	***6,646***	***740***	***140***	***85***
Open Space	***523,050***	***331,268***	***143,889***	***1,499***	***40,429***	***25,531***	***19,231***
Forest	345,289	166,290	38,649		9		16,641
Native Vegetation	21	0.09					
Rangeland	177,740	164,978	105,240	1,499	40,421	25,531	2,590
Unclassified	***11***		***141***				
Urban	***35,742***	***18,075***	***7,922***	***44,252***	***9,849***	***298***	***2,372***
Commercial and Institutional	1,520	835	501	1,047	153	17	82
Industrial	4,181	2,796	753	3,681	579	60	134
Residential (uncategorized)	9,770	3,508	223	4,385			620
Residential High Density	92	55	16	3	25		
Residential Low Density	7,170	1,192	550	946	1,880		208
Transitional	4,454	1	99	201			
Transportation, Communication, Utilities	2,249	6,720	1,253	3,393	1,248	200	728
Urban (other or mixed)	6,305	2,967	4,527	30,595	5,965	21	600
Water	***4,773***	***13,909***	***838***	***965***	***284***	***88***	***150***
Wetland and Marsh	***5,709***	***34,650***	***44***	***587***	***33***	***30***	***244***
Total Acreage	**809,432**	**1,103,271**	**256,734**	**116,159**	**94,659**	**42,207**	**102,447**
Land Use as Percentage of Total Acreage							
Agriculture	29%	63%	40%	51%	46%	38%	78%
Barren	0.4%	0.26%		2.7%			0.004%
Open Recreation	0.3%	0.72%	0.58%	5.7%	0.78%	0.33%	0.08%
Open Space	65%	30%	56%	1.3%	43%	60%	19%
Unclassified	0.001%		0.05%				
Urban	4.4%	1.6%	3.1%	38%	10%	0.71%	2.3%
Water	0.6%	1.3%	0.33%	0.83%	0.30%	0.21%	0.15%
Wetland and Marsh	0.7%	3.1%	0.02%	0.51%	0.03%	0.07%	0.24%

Table C.17: Non-303(d)-Listed Watersheds Required by the Proposed Basin Plan Amendments to Reduce Their Methylmercury Exports to the Delta/Yolo Bypass – *MS4s*.

MS4	Cosumnes River	Colusa Basin	French Camp Slough	Morrison Creek	Ulatis Creek	Upper Lindsay/ Cache Slough	Willow Slough
Calaveras (County)			X				
Davis (City)							X*
El Dorado (County)	X						
El Dorado Hills (City)	X						
French Camp (CDP)			X				
Kennedy (CDP)			X				
Sacramento MS4 Area	X			X			
San Joaquin (County)	X		X				
Solano (County)					X	X	
Stanislaus (County)			X				
Stockton MS4 Area			X				
Vacaville (City)					X		
Woodland (City)							X*
Yolo (County)		X					X

* Outlying areas of Woodland and Davis may drain to Willow Slough. The future watershed source analysis would re-evaluate the hydrology of the region to confirm MS4 service areas that discharge in each watershed.

K. LOCAL & STATEWIDE AIR EMISSIONS

Atmospheric deposition of mercury in the Delta and its tributary watersheds needs to be capped at existing levels. Atmospheric deposition is a statewide issue and some sources originate outside of the state. The proposed Basin Plan amendments include the recommendation that the USEPA, State Water Board, and Air Resources Board should develop a memorandum of understanding to conduct studies to evaluate local and statewide mercury air emissions and deposition patterns and to develop options for a load reduction program(s). Characterization and control studies could involve characterizing current mercury emissions from facilities in California and local and statewide mercury atmospheric deposition rates, differentiating mercury deposition sources as local or out-of-state, and investigating mercury emission controls for local sources.

An ongoing CALFED atmospheric mercury deposition study has a budget of $440,000 (SJSU, 2005). The study includes three atmospheric wet deposition monitoring stations (California Coast, Central Valley, and Sierra) with bi-weekly sampling for 28 to 30 months. The study also included preliminary investigations into the importance of dry deposition flux of mercury.

Potential costs for a Delta-specific characterization study could range from about $1.5 to $3.0 million. These estimates are based on costs associated with the before-mentioned CALFED study and the following assumptions:

- Evaluation of mercury emission data obtained from the Air Resources Board for facilities throughout the Delta, upwind of the Delta, and in its tributary watersheds to determine which facilities emit the most mercury and their locations: 40 hours at $100/hr.
- Atmospheric wet and dry deposition monitoring upwind of the Delta and in its tributary watersheds (e.g., upwind and downwind of major metropolitan areas such as the San Francisco Bay area, Sacramento, Stockton, Redding, and Fresno, and of facilities with high mercury emissions): 10 to 20 monitoring locations at $150,000 per location.
- Study design, fate and transport modeling, data analyses, and report writing: 480 hours at $100/hr.

The area upwind of the Delta, the Delta, and its tributary watersheds account for about 30% of California. Expanding the Delta-region study to a statewide study would likely cost twice as much, about $3 to $6 million. Only the cost estimates for the Delta-specific evaluation are included in Table 4.4.

Cement and concrete manufacturing facilities and crematories in the Delta source region appear to have the highest mercury emissions of the different facility types that submit mercury emission data to the Air Resources Board (see Appendix K in the TMDL Report). Measures are being developed to control mercury emitted by coal-fired power plants; however, few measures are under development for other industries. The two major approaches under development for controlling mercury emissions from coal-fired power plants are multi-pollutant controls (using current controls for SO_2, NO_x, and particulate matter) and mercury-specific controls (activated carbon injection (ACI)) (Srivastava, 2004). Multi-pollutant control strategies employ control methods currently used for other constituents that also effectively control mercury in emissions.

A possible control study could include determining the efficiency of current coal-fired mercury control measures for other industries. Table C.18 shows the estimated costs of installing mercury control measures for coal-fired power plants, as well as one measure specifically for cement kilns. The mercury control costs range from $194,000 to $3.7 million/yr/facility. Until the previously discussed atmospheric deposition characterization study is conducted, it is not known whether any facilities will need to reduce their mercury emissions; as a result, mercury control costs for mercury emissions are not included in Table 4.4.

Table C.18: Estimated Costs of Mercury-Specific and Multi-pollutant Emission Controls

Control Method	Primary Constituent Control	Design Capacity Used for Estimate	Total Annual Cost (a)
Selective Noncatalytic Reduction (SNCR) Control for a Boiler (b)	NO_x	250 MMBtu/hr (c) to 6000 MMBtu/hr	$194,468
Selective Catalytic Reduction (SCR) (b)	NO_x	463,138 acfm (c)	$1,856,715
Packed Tower Absorber (b)	SO_2	22,288 acfm	$540,552
Fabric Filter System (b)	Particulate Matter	50,000 acfm	$605,725
Wet Scrubbers (b)	Particulate Matter	75,000 acfm	$335,896
Electrostatic Precipitator (ESP) System Carbon Absorber System (b)	Particulate Matter	50,000 acfm	$706,679
Activated Carbon Injection (ACI) for a Cement Kiln (d)	Hg and PM	1 kiln	$506,000 to $3.9 million

(a) Total annual costs are based on 20-year project lives and include all costs incurred by the installation (e.g. administration, O&M, overhead, labor).
(b) USEPA, 2002. EPA Air Pollution Control Cost Manual, Sixth Edition.
(c) MMBtu: million British thermal units; acfm: actual cubic feet per minute.
(d) USEPA, 2005. Costs include the carbon injection system in addition to the baghouse (particulate matter control measure) necessary to collect the carbon.

L. RISK REDUCTION EFFORTS

An expanded public outreach, education, and human health risk management program is a component of each implementation alternative, even the no action alternative. CDPH, agencies proposing new wetland projects in Delta/Yolo Bypass that have the potential to increase methylmercury discharges to surface waters, and NPDES permitted WWTPs and MS4s (see Section 4.3.2) need to develop and implement programs to reduce mercury related health risks. The dischargers need to work with affected communities, CDPH, OEHHA, and county health departments to develop a strategy for expanding and sustaining existing public education and outreach programs.

The pollution prevention measures required for NPDES permittees contain public outreach and education components regarding the use and disposal of mercury-containing products. Dischargers could integrate their public outreach and education programs with or contribute to risk management programs currently implemented by local and state health departments. OEHHA, CDPH, and local health departments currently implement programs to reduce the risk of consuming fish contaminated with mercury to the public.

Some risk management activities, particularly outreach and education, have been conducted in the Delta. Staff used these activities as a basis for cost estimates for future work. Since 2002, the CDPH Environmental Health Investigations Branch (EHIB) has been conducting public outreach and education activities regarding mercury and fish consumption in the area of the Sacramento-San Joaquin River Delta. These activities have been partially supported by the California Bay-Delta Authority and State bond funds, the Delta Tributaries Mercury Council, the Sacramento Regional County Sanitation District, the State Water Resources Control Board, and the Central Valley Water Board. Starting in 2005, EHIB worked with the Local Stakeholder Advisory Group (LSAG), a committed group of local fish consumers and representatives of community-based organizations (CBOs). The LSAG provided guidance on public outreach methods, developed and tested educational materials, and initiated and conducted outreach activities. Specifically for the Fish Mercury Project (CALFED-funded, integrated project for fish monitoring, risk communication, and advisory development[12]), the LSAG counseled on fish types and sites that are important to local consumers. The University of California, Davis, Department of Environmental Science and Policy also has coordinated collection of information about fish consumption and outreach needs in the Delta.[13]

Public outreach and education activities conducted in the Delta have included:

- Pilot consumption surveys with boaters, shore anglers, and pregnant women;
- Development of written consumption guidance and mercury risk information in multiple languages;

[12] The California Bay-Delta Authority's Ecosystem Restoration Program project #02D-P67 was conducted by the San Francisco Estuary Institute, CDFG Moss Landing Marine Laboratory, UC Davis, CDPH-EHIB, and OEHHA in 2005-2007. Project information and reports are available at: http://www.sfei.org/cmr/fishmercury.

[13] Shilling, F., L. Lippert and A. White. 2008. *Contaminated Fish Consumption in California's Central Valley Draft Report.* Dept. Environmental Science and Policy and Dept. Human and Community Development, University of California Davis. Report prepared for the Sacramento Regional County Sanitation District and the California Endowment. January.

- Outreach in community-based organizations and focus groups to obtain information on consumption of local fish, awareness of mercury issues and training needs, and methods of outreach most effective for different communities and ethnic groups;
- Development of curriculum and training of local health care providers; and
- Production of multi-language signs for placement at key angling and water access points in the Delta.

More funds and time need to be committed to education and outreach in the Delta. Future activities could include: outreach to more people, particularly pregnant and nursing women and children who eat fish, working with CBOs to determine the most effective methods of communication for different communities and ethnic groups; completed placement and maintenance of Delta fish warning signs; development of educational media for radio and television; increased partnerships with health care providers to provide patients with general information or individual risk assessment; a comprehensive fish consumption survey of people who eat Delta fish; monitoring human hair or blood to better evaluate methylmercury intake; developing methods of risk reduction that go beyond education (e.g., alternative fish or protein sources); and evaluation of the effectiveness of various outreach methods.

Funding is needed for participation as well as projects. Fish consumers, members of CBOs and other representatives of fish-consuming groups take time from their regular activities and jobs to participate in risk management efforts and meetings. Providing these individuals and groups with modest compensation for their time is often needed in order for them to continue participating. Inclusion of CBOs and members of the affected communities in planning and conducting risk management measures is critical to the effort's success.

The Basin Plan amendments propose to continue and expand these programs. The total program cost for expanded public outreach and education is about $390,000/yr, based on the following assumptions:

- The CALFED Fish Mercury Project allotted $968,931 over three years to perform the stakeholder organization and public outreach and education activities described above (FMP, 2005a). On a yearly basis, the project spent about $323,973.
- Some of the LSAG's time for the FMP was spent to guide selection of fish monitoring sites, which will not need to occur on a yearly basis. Print materials in multiple languages have already been developed. However, in order to sustain the message to fish consumers already reached while expanding the program, Central Valley Water Board staff estimates that increased funding will be needed in the future for the risk reduction program.

Staff multiplied the FMP's yearly public outreach (rounded) cost by 1.2 – an increase of 20% – to calculate potential yearly costs for the BPA's outreach program in the Delta.

M. TAC COORDINATION, REPORTING TO THE BOARD & ADAPTIVE MANAGEMENT EFFORTS

1. Development of a Technical Advisory Committee, Phase 1 Studies Coordination & Progress Reports to the Board

Staff highly recommends that a technical advisory committee (TAC) of five to seven independent, nationally or internationally recognized mercury experts be formed to review study designs, evaluate results, propose follow up experiments and make recommendations on whether sufficient information is available to implement methylmercury management practices. TAC members should have a collective breadth of experience and knowledge on mercury research and application.

The Figure C.2 illustrates potential tasks and a hypothetical timeline for methylmercury characterization and control study development and coordination with the TAC. Staff developed this timeline based on experience with USEPA Science Advisory Boards and CALFED's Mercury Program technical review panels. The charge of the Mercury Program technical review panels was to evaluate and comment on the technical information, analyses, results and conclusions from the mercury-related research and monitoring projects, in consideration of CALFED's Ecosystem Restoration Program goals, resource constraints, and other administrative limitations. Table C.19 summarizes the panel cost assumptions that CALFED staff used to develop their panel meeting budget, adjusted for the number of meetings and panelists likely to be needed for the proposed TAC.

Based on the tasks outline in Figure C.2 and potential TAC meeting costs in Table C.19, staff estimates that approximately $250,000 will be required to fund the TAC, and that at least one Central Valley Water Board staff person at 25% time over the eight-year Phase 1 study period (8 yrs x 500 hours per year x $70/hr = $280,000) will be required to develop "study fact sheets" for TAC and public review, prepare review packages for the TAC, coordinate TAC meetings, review study progress reports, and report progress to the Central Valley Water Board members.

Some funding for the TAC may be available from CALFED or the USEPA. As a result, staff expects potential costs for the TAC and study coordination to range from $300,000 to $500,000.

2. Re-evaluation of the Delta Methylmercury TMDL and Implementation Program at the End of Phase 1

Staff will re-evaluate the Delta Methylmercury TMDL and implementation program and develop additional Basin Plan amendments as needed at the end of Phase 1 to adapt the Delta mercury control program using new scientific and policy information. Assuming that this effort will take 12 months of full-time effort of at least one staff person (1,920 hours @ $70/hr to $100/hr), the cost for re-evaluation could range from about $130,000 to $190,000.

3. Periodic Evaluation and Adaptation of the Control Program during Phases 2 and 3

Staff will periodically evaluate and modify the control program with Board approval during Phases 2 and 3 based on new information from monitoring, special studies, and scientific literature. Assuming re-evaluation efforts will occur three times in the next 30 years, and each re-evaluation would require three to six months of full-time effort of at least one staff person (480 to 960 hours @ $70/hr to $100/hr), the cost of staff time could range from about $100,800 to $288,000 (about $3,400/yr to $9,600/yr, when averaged over 30 years).

Table C.19: Potential Budget for Four Two-Day TAC Meetings

	Low Cost Estimate	**High Cost Estimate**	**Comments** [(a)]
Panelist Stipends	$12,000	$16,800	$1200 per day per panelist; low estimate: 5 paid panelists; high estimate: 7 paid panelists.
Extra Stipends for Panelists Who Travel From out of State	$0	$8,400	High estimate: assumes 7 panelists travel from out of state and receive one extra day's stipend ($1,200) for travel.
Panelist Travel Expenses	$250	$4,200	Low estimate: mileage for 5 panelists; high estimate: $600 plane fare for 7 panelists.
Panelist Lodging Expenses	$0	$2,730	High estimate: hotel lodging for 7 panelists, 3 nights each at $130/night.
Room Rental	$0	$1,000	State meeting rooms typically have no cost; high estimate is for a meeting room at a hotel.
Catering/Food	$500	$3,000	Assumes food for guests as well as panelists.
IT / AV Charges	$0	$500	
Subtotal:	**$12,750**	**$36,630**	
Overhead (15%): [(b)]	$1,913	$5,495	
Total for One Two-Day Meeting:	**$14,663**	**$42,125**	
Total for Four Two-Day Meetings:	**$58,652**	**$168,500**	

(a) Cost assumptions used by CALFED staff to budget for Mercury Program technical review panel meetings (A. Barnes, 2007).
(b) There would be no overhead charge if State staff, rather than contractors, coordinated the meetings.

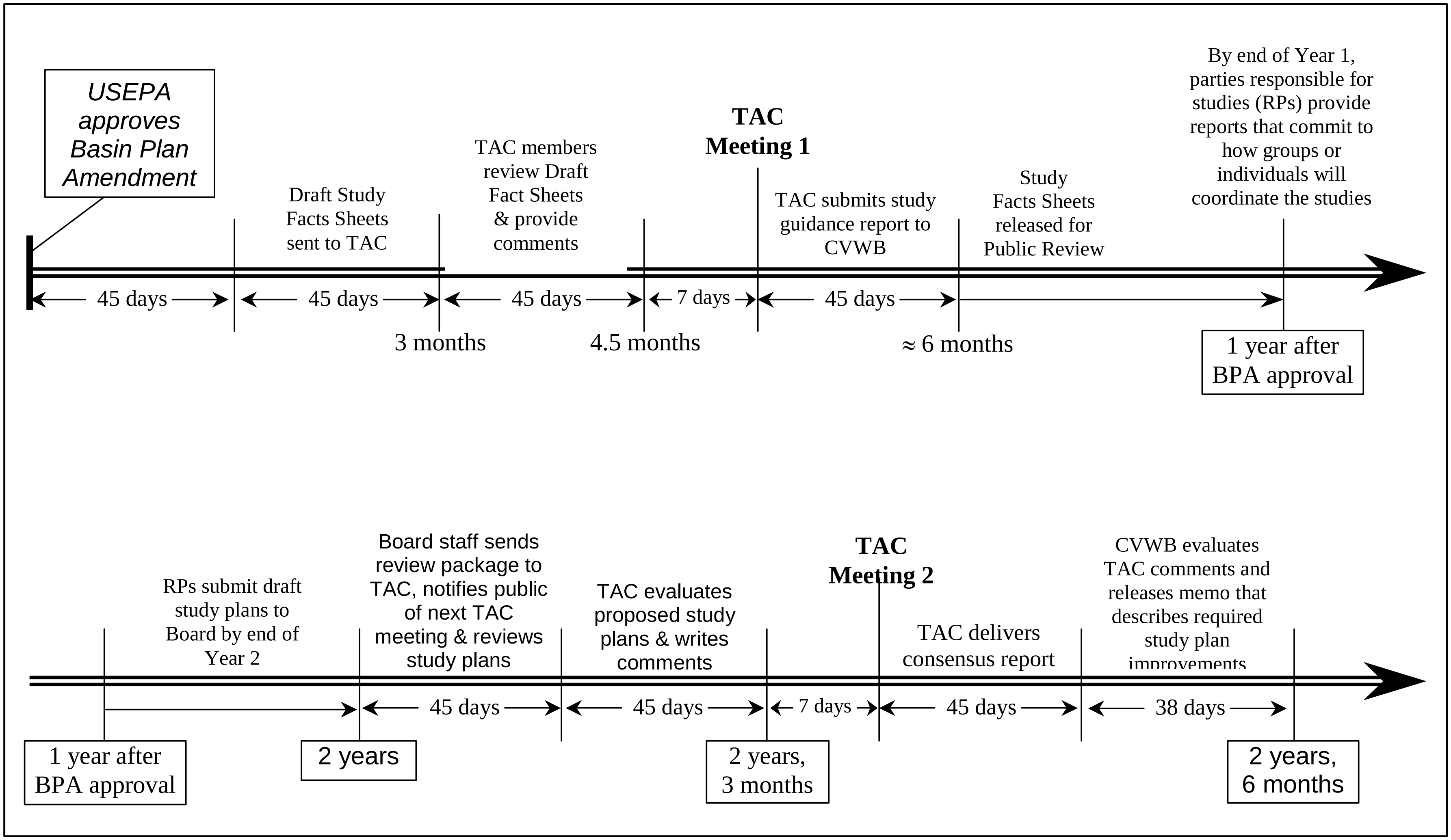


Figure C.2(a): Hypothetical Timeline for Methylmercury Characterization and Control Study Development and Technical Advisory Committee (TAC) Review

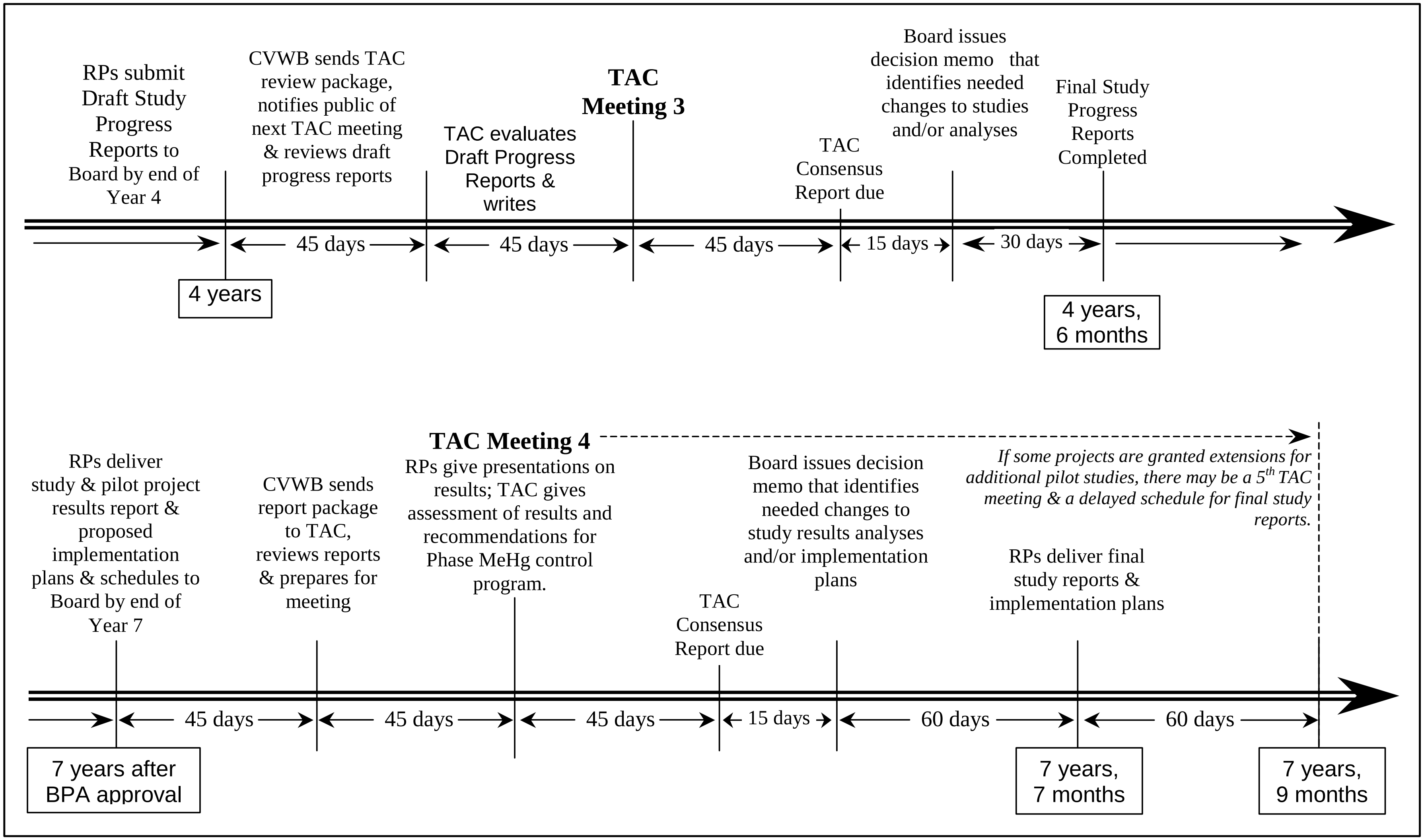


Figure C.2(b): Hypothetical Timeline for Methylmercury Characterization and Control Study Development and Technical Advisory Committee (TAC) Review

N. SURVEILLANCE AND MONITORING PROGRAM

A surveillance and monitoring program is an essential element of the methylmercury control strategy for the Delta. The recommended monitoring program includes total mercury fish tissue monitoring and total and methyl mercury water monitoring in the Delta and Yolo Bypass to commence after total mercury and methylmercury control actions have taken place. The proposed Basin Plan amendment language outlines eight monitoring locations throughout the Delta and Yolo Bypass and recommends that additional locations be established once the methylmercury fish tissue objectives have been achieved in a particular subarea.

1. Fish Monitoring

Fish monitoring costs could range from about $72,000 to $120,000 per sampling event ($7,200/yr to $12,000/yr, given a 10-year sampling frequency), based on the following assumptions:

- Sampling frequency: Initiate sampling five years after dischargers implement projects to reduce methylmercury and total mercury discharges (e.g., 2020), then every ten years thereafter.
- Number of samples per location & sampling locations: Collect nine single-fish samples of largemouth bass from a range of sizes (150-500 mm) for trend analysis at the eight long-term compliance monitoring reaches, along with three composite samples (e.g., three fish combined in one sample) from two additional TL4 species (average 300-400 mm), three TL3 species (average 300-400 mm), and two TL2/3 species (<50 mm). Collect composite samples of largemouth bass and the other TL2/3/4 species at additional locations when the fish tissue objectives are met in a given subarea (assumed not to exceed 8 additional locations). There would be 8 to 16 sampling locations during any given sampling event, and 30 samples per compliance reach and 24 samples at each additional location.
- Total mercury analysis cost per fish sample: $180 ($150/sample plus 20% for field and laboratory QA/QC samples).
- Sampling labor cost: $2,100 per sampling location.
- Data analysis, report writing, administration and reporting to the Board: 120 hours per sampling event at $100/hr.

2. Water Monitoring

The aqueous methylmercury goal of 0.06 ng/l for ambient Delta water is the annual, average concentration in unfiltered samples. For the comparison of Delta and tributary waterways' methylmercury concentration data with the aqueous methylmercury goal, water samples should be collected periodically throughout the year and during typical flow conditions as they vary by season, rather than targeting extreme low or high flow events. Ambient water monitoring should take place at the same eight locations as the fish methylmercury compliance monitoring described in the proposed Basin Plan amendment language as well as where tributaries enter the Delta and Yolo Bypass (Table G in the proposed amendment language) The proposed amendment language states that ambient water monitoring should take place for at least one year before the fish tissue objective compliance monitoring takes place.

Ambient water monitoring costs could range from about $75,100 to $169,600 per sampling event ($7,500/yr to $17,000/yr, given a 10-year sampling frequency), based on the following assumptions:

- Sampling frequency: 6 to 10 sampling events over the year (bi-monthly sampling at a minimum, more often depending on seasonal and hydrological conditions).
- Number of sampling locations: 8 fish compliance monitoring sites and 8 to 16 tributary input sites (depending on the timing of mercury control actions in specific tributary watersheds). Staff assumed that a two-person sampling team could sample four sites per 8-hour day at $140/hr.
- The following water analyses would be performed for each sample: unfiltered methyl and total mercury, and SSC. Analysis costs would include an additional 20% for field and laboratory QA samples.
- Data analysis, report writing, administration and reporting to the Board: 120 hours per one-year sampling period at $100/hr.

O. METHYL & TOTAL MERCURY OFFSET PROGRAM

1. Development of Phase 1 Pilot Offset Projects

The implementation of pilot offset projects during Phase 1 would constitute a voluntary effort on the part of dischargers. Implementation of many watershed projects to reduce total mercury and methylmercury loads is expected to take place during Phase 1 and Phase 2 even if there were no Phase 1 pilot projects or Phase 2 offset program. Completion of voluntary pilot offset projects would result in cleanup actions taking place more quickly. There are substantial administrative and coordination efforts associated with obtaining approval for Phase 1 pilot offset projects.

A pilot offset project credit strategy needs to be developed and approved by the Central Valley Water Board in coordination with the State Board, USEPA, dischargers and other stakeholders for each offset project ($150,000 for 1,500 hours spent by all entities involved at $100/hr for each project). To date, only one discharger has expressed interest in conducting a pilot offset project. Assuming that a total of three dischargers may volunteer to conduct pilot projects during Phase 1, and that the process would be simpler for the second and third projects, the overall cost of developing pilot offset project credit strategies for three projects could be about $300,000.

As outlined in the proposed Basin Plan amendments, staff recommends that credit accrued by dischargers for successful pilot offset projects be used to extend Phase 2 time schedules for compliance with methylmercury load allocations by five years. However, there could be substantial administrative and implementation costs associated with a pilot project conducted in a watershed different from the project proponent's own discharge, particularly if its accrued credit were used to allow the project proponent to increase its discharge over an indefinite period (e.g., versus a five year extension of its allocation compliance schedule). For example, if a project proponent discharges to the San Joaquin subarea of the Delta, but implements a pilot project in the Cache Creek watershed, which discharges to the Yolo Bypass subarea, the pilot project would result in no improvement for the San Joaquin subarea. If the project proponent wanted to use its accrued offset credits for its discharge to the San Joaquin subarea, it may be necessary to adjust methylmercury allocations to reduce the other discharges to the San Joaquin subarea to ensure that the fish tissue objectives are met in the San Joaquin subarea. The costs of such implementation scenarios will be further evaluated once specific credit strategies have been approved for particular offset projects.

2. Development of Phase 2 Offset Program

Development and approval of a Phase 2 offset program has been and will continue to be a labor-intensive effort that involves extensive coordination and collaboration between the Central Valley Water Board, State Board, USEPA, dischargers and other stakeholders ($150,000 for 1,500 hours spent by all entities involved at $100/hr). In addition, implementing an offset program would require a Basin Plan amendment with associated public workshops, supporting documentation for an implementation alternatives analysis and evaluation of environmental impacts and potential costs, and a Board hearing. Basin Planning efforts are expected to require at least one staff person at 20% time during the first seven years of the eight-year Phase 1 period (7 yrs x 400 hours per year x $100/yr = $280,000). During the year prior to the Board hearing, Basin Planning efforts are expected to require one staff person working full time and one staff person working at 50% time ((1,920 hours + 1,000 hours) x $100/hr = $292,000).

In addition to inter-agency coordination and Basin Planning efforts, additional studies may be needed to support the development of a Phase 2 offset program. For example, to determine long-term offset credit strategies, there needs to be an evaluation of the relative potential for inorganic mercury and/or methylmercury from different sources (e.g., the project proponent's discharge compared to the pilot offset project's discharge) to enter the food web in the Delta and Yolo Bypass. Such an evaluation could entail a variety of components – e.g., literature review, analyses of available data, and laboratory and field studies – that could cost about $400,000, given estimates discussed in previous sections.

Overall costs associated with developing a Phase 2 offset program could range from $722,000 to $1.1 million, depending on whether or not additional studies are conducted.

3. Early Implementation of Total Mercury Reduction Efforts

In addition to accumulating offset credits by implementing Central Valley Water Board approved pilot mercury offset projects, staff recommends that the Board consider approving credit for dischargers that can demonstrate early reduction of their total mercury discharges. Dischargers could accrue methylmercury or total mercury credits that may be used to extend the Phase 2 time schedules by up to five years for compliance with methylmercury allocations. Administrative costs to develop the credit strategy are encompassed with the estimated costs to develop the pilot offset project credit strategy.

As with the credit strategy for pilot offset projects, early implementation of total mercury discharge reduction efforts could result in more immediate fish mercury reductions. Use of accrued credit is expected to reduce the overall cost of compliance with the proposed methylmercury allocations under both Alternatives 2 and 3. However, there could be substantial administrative and implementation costs associated with use of accrued credit to allow a discharger to increase its discharge over an indefinite period (e.g., versus a five year extension of its allocation compliance schedule). For example, if a discharger in the San Joaquin subarea wanted to use its accrued credits later in Phase 2 or Phase 3 of the Delta TMDL implementation to allow it to increase its discharge, it may be necessary to adjust methylmercury allocations to reduce the other discharges to the San Joaquin subarea to ensure that fish tissue objectives continue to be met in the San Joaquin subarea. The costs of such implementation scenarios will be further evaluated once specific credit strategies have been approved for particular offset projects.

P. SUPPORTING INFORMATION FOR WWTP COST CONSIDERATIONS

Table C.20: Characteristics of NPDES-Permitted Facilities within the Delta/Yolo Bypass and Tributary Watersheds Downstream of Major Dams that May Be Affected by Implementation Alternatives 2 and 3.

Facility (NPDES No.)	Type of Facility	Flow (mgd)	Average Effluent MeHg Conc (ng/l) [(a)]	Proximity to Delta/ Yolo Bypass [(b)]	Delta Subarea that Ultimately Receives Discharge	Discharges to 2006 303(d) Hg-Listed Waterway
Anderson WWTP (CA0077704)	Mun WWTP	1.40	0.090	Upstream	Sac.R./Yolo B.	
Atwater WWTP (CA0079197)	Mun WWTP	3.40	0.034	Upstream	San Joaquin River	
Auburn WWTP (CA0077712)	Mun WWTP	1.17	0.028	Upstream	Sacramento River	
Brentwood WWTP (CA0082660)	Mun WWTP	3.09	0.010	Within	Marsh Creek	X
CA State of, Central Heating/Cooling Facility (0078581)	Heating/ Cooling	5.26	0.015	Within	Sacramento River	X
Chico Regional WWTP (CA0079081)	Mun WWTP	7.20	0.157	Upstream	Sac.R./Yolo B.	X
Corning Industries/ Domestic WWTP (CA0004995)	Mun WWTP	1.00	0.044	Upstream	Sac.R./Yolo B.	X
Davis (City of) WWTP (CA0079049)	Mun WWTP	5.26	0.574	Within	Yolo Bypass	
Deuel Vocational Institute WWTP (CA0078093)	Mun WWTP	0.47	0.010	Within	San Joaquin River	X
Discovery Bay (City of) WWTP (CA0078590)	Mun WWTP	1.54	0.178	Within	Central Delta	X
El Dorado ID Deer Creek WWTP (CA0078662)	Mun WWTP	2.52	0.015	Upstream	Mok./Cos. R.	
El Dorado ID El Dorado Hills WWTP (CA0078671)	Mun WWTP	1.08	0.013	Upstream	Mok./Cos. R.	
Galt (City of) WWTP (CA0081434)	Mun WWTP	1.92	0.139	Upstream	Mok./Cos. R.	
GWF Power Systems (CA0082309)	Power	0.05	0.013	Within	West Delta	X
Lincoln WWTP (CA0084476)	Mun WWTP	1.13	0.018	Upstream	Sacramento River	
Linda Co Water Dist WWTP (CA0079651)	Mun WWTP	1.30		Upstream	Sac.R./Yolo B.	X
Live Oak WWTP (CA0079022)	Mun WWTP	1.60	0.591	Upstream	Sac.R./Yolo B.	
Lodi (City of) White Slough WWTP (CA0079243)	Mun WWTP	4.51	0.147	Within	Central Delta	X
Manteca (City of) WWTP (CA0081558)	Mun WWTP	4.63	0.216	Within	San Joaquin River	X
Mirant Delta CCPP (CA0004863)	Power	124	0.074/ 0.086	Within	West Delta	X
Oakwood Lake Subdivision Mining Reclamation (CA0082783)	Aggregate	9.15	0.027	Within	San Joaquin River	X
Merced WWTP (CA0079219)	Mun WWTP	8.50	0.386	Upstream	San Joaquin River	
Modesto (City of) WWTP (CA0079103)	Mun WWTP	7.22	0.125 / 0.140	Upstream	San Joaquin River	X
Mountain House CSD WWTP-1 (CA0084271)	Mun WWTP			Within	San Joaquin River	X
Olivehurst PUD WWTP (CA0077836)	Mun WWTP	1.80	0.144	Upstream	Sac.R./Yolo B.	
Oroville WWTP (CA0079235)	Mun WWTP	3	0.147	Upstream	Sac.R./Yolo B.	X

Table C.20: Characteristics of NPDES-Permitted Facilities within the Delta/Yolo Bypass and Tributary Watersheds Downstream of Major Dams that May Be Affected by Implementation Alternatives 2 and 3.

Facility (NPDES No.)	Type of Facility	Flow (mgd)	Average Effluent MeHg Conc (ng/l) [(a)]	Proximity to Delta/ Yolo Bypass [(b)]	Delta Subarea that Ultimately Receives Discharge	Discharges to 2006 303(d) Hg-Listed Waterway
Placer Co. SMD #1 WWTP (CA0079316)	Mun WWTP	1.95	0.141	Upstream	Sacramento River	
Proctor & Gamble Co. WWTP (CA0004316)	Manufacturing	5.50	0.010 / 0.033	Upstream	Sacramento River	
Red Bluff WWRP (CA0078891)	Mun WWTP	1.40	0.030	Upstream	Sac.R./Yolo B.	
Redding Clear Creek WWTP (CA0079731)	Mun WWTP	7.50	0.042	Upstream	Sac.R./Yolo B.	
Redding Stillwater WWTP (CA0082589)	Mun WWTP	3.46	0.013	Upstream	Sac.R./Yolo B.	
Rio Vista Main WWTP (CA0079588)	Mun WWTP	0.47	0.164	Within	Sacramento River	X
Rio Vista Trilogy WWTP / Northwest WWTP (CA0083771)	Mun WWTP	3.00		Within	Sacramento River	X
Roseville Dry Creek WWTP (CA0079502)	Mun WWTP	13.00	0.023	Upstream	Sacramento River	
Roseville Pleasant Grove WWTP (CA0084573)	Mun WWTP	4.82	0.017	Upstream	Sacramento River	
Sacramento Combined WWTP (CA0079111)	Mun WWTP (Comb.)	1.28		Within	Sacramento River	X
San Joaquin Co DPW - Flag City WWTP (CA0082848)	Mun WWTP	0.06	0.081	Within	Central Delta	X
SRCSD Sacramento River WWTP (CA0077682)	Mun WWTP	151	0.727	Within	Sacramento River	X
SRCSD Walnut Grove WWTP (CSD1) (CA0078794)	Mun WWTP	0.08	2.155	Within	Sacramento River	X
Stockton (City of) WWTP (CA0079138)	Mun WWTP	27.78	0.935	Within	San Joaquin River	X
Tracy (City of) WWTP (CA0079154)	Mun WWTP	9.49	0.145	Within	San Joaquin River	X
Turlock (City of) WWTP (CA0078948)	Mun WWTP	11.71	0.060	Upstream	San Joaquin River	X
UC Davis WWTP (CA0077895)	Mun WWTP	1.92	0.038	Upstream	Yolo Bypass	X
Vacaville Easterly WWTP (CA0077691)	Mun WWTP	9.26	0.024	Upstream	Yolo Bypass	
West Sacramento WWTP (CA0079171)	Mun WWTP	5.60	0.050	Within	Sacramento River	X
Woodland WWTP (CA0077950)	Mun WWTP	6.05	0.031	Within	Yolo Bypass	
Yuba City WWTP (CA0079260)	Mun WWTP	5.50	0.295	Upstream	Sac.R./Yolo B.	X

(a) Some facilities have more than one discharge.

(b) All facilities that discharge directly to the Delta and Yolo Bypass and facilities that discharge greater than 1 mgd to upstream waterways are listed; smaller facilities in the upstream watersheds are not affected by any of the implementation alternatives.

Table C.21: Treatment Processes Employed by NPDES-Permitted Facilities within the Delta/Yolo Bypass and Tributary Watersheds Downstream of Major Dams that May Be Affected by Implementation Alternatives 2 and 3.

Facility	WY2005 Effluent Volume (mgd)	Discharge to 2006 303(d) Hg-Listed Waterway	Primary Clarification	Activated Sludge	Pure Oxygen Activated Sludge	RBC's	SBR's	Fixed Film Reactors	Trickling Filters	Extended Aeration	Pond System (a)	Oxidation Ditch	Nitrification / Denitrification	Secondary Clarification	Dissolved Air Flotation	Coagulation / Polymer	Microfiltration	Filtration	Chlorination	Chlorination / Dechlorination	Ultraviolet Radiation
Anderson WWTP	1.40			X										X				X		X	
Atwater WWTP	3.40		X	X										X						X	
Auburn WWTP	1.17											X	X	X		X		X		X	
Brentwood WWTP	3.09	X	X							X		X	X	X		X		X	X		
Chico Regional WWTP	7.20	X	X	X						X				X					X		
Corning Industries/ Domestic WWTP	1.00	X										X		X						X	
Davis (City of) WWTP	5.26		X								X									X	
Deuel Vocational Institute WWTP	0.47	X										X	X	X				X	X		
Discovery Bay (City of) WWTP	1.54	X										X	X	X							X
El Dorado ID Deer Creek WWTP	2.52		X	X						X		X	X					X		X	
El Dorado ID El Dorado Hills WWTP	1.08		X	X									X		X			X	X		
Galt (City of) WWTP	1.92			X						X				X						X	
Lincoln WWTP	1.13											X	X		X	X		X			X
Linda Co Water Dist WWTP (CA0079651)	1.30	X	X						X					X						X	
Live Oak WWTP	1.60										X									X	
Lodi (City of) White Slough WWTP	4.51	X	X	X										X				X			X
Manteca (City of) WWTP	4.63	X	X	X										X						X	
Oakwood Lake Subdivision Mining Reclamation	9.15	X									X										
Merced WWTP	8.50		X	X										X						X	
Modesto (City of) WWTP	7.22	X	X					X			X									X	
Mountain House CSD WWTP-1		X					X									X		X		X	
Olivehurst PUD WWTP	1.80		X	X										X						X	
Oroville WWTP	3	X	X	X										X				X		X	
Placer Co. SMD #1 WWTP	1.95		X			X			X					X				X		X	
Proctor & Gamble Co. WWTP	5.50																				
Red Bluff WWRP	1.40		X	X										X				X		X	
Redding Clear Creek	7.50		X	X										X				X		X	

Table C.21: Treatment Processes Employed by NPDES-Permitted Facilities within the Delta/Yolo Bypass and Tributary Watersheds Downstream of Major Dams that May Be Affected by Implementation Alternatives 2 and 3.

Facility	WY2005 Effluent Volume (mgd)	Discharge to 2006 303(d) Hg-Listed Waterway	Primary Clarification	Activated Sludge	Pure Oxygen Activated Sludge	RBC's	SBR's	Fixed Film Reactors	Trickling Filters	Extended Aeration	Pond System (a)	Oxidation Ditch	Nitrification / Denitrification	Secondary Clarification	Dissolved Air Flotation	Coagulation / Polymer	Microfiltration	Filtration	Chlorination	Chlorination / Dechlorination	Ultraviolet Radiation
WWTP																					
Redding Stillwater WWTP (CA0082589)	3.46			X														X		X	
Rio Vista Main WWTP	0.47	X	X	X										X						X	
Rio Vista Trilogy WWTP / Northwest WWTP	3.00	X	X						X					X				X			
Roseville Dry Creek WWTP	13.00		X	X									X			X		X		X	
Roseville Pleasant Grove WWTP	4.82			X								X	X			X				X	
Sacramento Combined WWTP	1.28	X	X																X		
San Joaquin Co DPW - Flag City WWTP	0.06	X								X				X				X		X	
SRCSD Sacramento River WWTP	151.42	X	X		X									X						X	
SRCSD Walnut Grove WWTP (CSD1)	0.08	X									X									X	
Stockton (City of) WWTP	27.78	X	X						X		X							X		X	
Tracy (City of) WWTP	9.49	X	X	X					X					X						X	
Turlock (City of) WWTP	11.71	X		X										X						X	
UC Davis WWTP	1.92	X										X	X	X				X			X
Vacaville Easterly WWTP	9.26		X	X										X						X	
West Sacramento WWTP	5.60	X	X	X									X	X						X	
Woodland WWTP	6.05											X		X						X	
Yuba City WWTP	5.50	X	X		X									X						X	

(a) Pond systems include settling, oxidation, facultative, lemna ponds.

Table C.22: Current Permit Requirements for, and Monitoring Conducted by, NPDES-Permitted Facilities within the Delta/Yolo Bypass and Tributary Watersheds Downstream of Major Dams that May Be Affected by Implementation Alternatives 2 and 3.

Facility	Current Permit Requirements			Current Monitoring	
	Tot Hg Reduction Program [a]	Pretreatment Program	Pollution Reduction Program for Any Other Constituent	TotHg Monitoring Frequency	MeHg Monitoring Frequency
Anderson WWTP		X		Annual	
Atwater WWTP		X			
Auburn WWTP				Monthly	
Brentwood WWTP	X	X	X	Monthly	
California, State of, Central Heating/ Cooling Facility			X		
Chico Regional WWTP		X		Quarterly	
Corning Industries/ Domestic WWTP		X		Quarterly	
Davis (City of) WWTP		X	X	Monthly	
Deuel Vocational Institute WWTP			X		
Discovery Bay (City of) WWTP			X	Monthly for 1 yr, Quarterly thereafter	
El Dorado ID Deer Creek WWTP		X		Monthly	
El Dorado ID El Dorado Hills WWTP	X			Monthly	
Galt (City of) WWTP		X	X	Annual	
GWF Power Systems			X	Quarterly	
Lincoln WWTP	X		X	Annual	
Linda Co Water Dist WWTP				Annual	
Live Oak WWTP				Monthly	
Lodi (City of) White Slough WWTP	X	X		Monthly	
Manteca (City of) WWTP	X	X	X	Monthly	
Merced WWTP		X		Biannual	
Mirant Delta LLC Contra Costa Power Plant				Biannual	
Modesto (City of) WWTP	X	X	X	Monthly	
Mountain House CSD WWTP-1	X	X	X	Monthly	Monthly
Oakwood Lake Subdivision Mining Reclamation				Monthly	
Olivehurst PUD WWTP				Annual	
Oroville WWTP		X		Annual	
Placer Co. SMD #1 WWTP		X		Quarterly	
Proctor & Gamble Co. WWTP				Quarterly	
Red Bluff WWRP				Annual	
Redding Clear Creek WWTP		X		Annual	
Redding Stillwater WWTP		X		Annual	
Rio Vista Main WWTP	X		X	Quarterly	
Rio Vista Trilogy WWTP / Northwest WWTP				Quarterly	
Roseville Dry Creek WWTP	X	X		Quarterly	

Table C.22: Current Permit Requirements for, and Monitoring Conducted by, NPDES-Permitted Facilities within the Delta/Yolo Bypass and Tributary Watersheds Downstream of Major Dams that May Be Affected by Implementation Alternatives 2 and 3.

Facility	Current Permit Requirements			Current Monitoring	
	Tot Hg Reduction Program [a]	Pretreatment Program	Pollution Reduction Program for Any Other Constituent	TotHg Monitoring Frequency	MeHg Monitoring Frequency
Roseville Pleasant Grove WWTP	X	X		Quarterly	
Sacramento Combined WWTP [b]					
San Joaquin Co DPW - Flag City WWTP			X	Monthly	
SRCSD Sacramento River WWTP	X	X	X	Monthly	Variable
SRCSD Walnut Grove WWTP (CSD1)			X	Monthly	
Stockton (City of) WWTP	X	X	X	Monthly	
Tracy (City of) WWTP	X	X	X	Monthly EFF & INF, Quarterly RW, permittee states EFF & INF are 24-hour composites	
Turlock (City of) WWTP	X	X		Monthly	
UC Davis WWTP				Biannual	
Vacaville Easterly WWTP	X	X		Annual	
West Sacramento WWTP		X		Monthly	
Woodland WWTP		X		Monthly	
Yuba City WWTP		X		Monthly	

(a) Total mercury reduction programs include pollution prevention plans defined by Section 13263.3 of the California Water Code and other mercury minimization efforts required by individual permits.
(b) Sacramento Combined WWTP typically discharges as a result of major storm events

Table C.23: Potential Requirements Associated with Implementation Alternatives 2 and 3 for NPDES-Permitted Facilities within the Delta/Yolo Bypass and Tributary Watersheds Downstream of Major Dams

	Alternative 2		Alternative 3			
Facility	Monitor MeHg & Tot Hg in Effluent & Receiving Water for MeHg Allocation [(a)]	Participate in Characterization & Control Study	Monitor MeHg & Tot Hg in Effluent & Receiving Water for MeHg Allocation [(a)]	Participate in Characterization & Control Study	Monitor MeHg in Effluent for Phase 1 MeHg Concentration Limit	Implement TotHg Minimization Program
Anderson WWTP				X	M	X
Atwater WWTP					M	X
Auburn WWTP					M	X
Brentwood WWTP	M		M		M	X
California, State of, Central Heating/ Cooling Facility	Q		Q		Q	
Chico Regional WWTP				X	M	X
Corning Industries/ Domestic WWTP					M	X
Davis (City of) WWTP	M	X	M	X	M	X
Deuel Vocational Institute WWTP	Q		Q		Q	
Discovery Bay (City of) WWTP	M		M		M	X
El Dorado ID Deer Creek WWTP					M	X
El Dorado ID El Dorado Hills WWTP					M	X
Galt (City of) WWTP				X	M	X
GWF Power Systems	Q		Q		Q	
Lincoln WWTP					M	X
Linda Co Water Dist WWTP					M	X
Live Oak WWTP				X	M	X
Lodi (City of) White Slough WWTP	M		M		M	X
Manteca (City of) WWTP	M	X	M	X	M	X
Merced WWTP				X	M	X
Mirant Delta LLC Contra Costa Power Plant	Q		Q		Q	
Modesto (City of) WWTP				X	M	X
Mountain House CSD WWTP-1	M	X	M	X	M	X
Oakwood Lake Subdivision Mining Reclamation	Q		Q		Q	
Olivehurst PUD WWTP				X	M	X
Oroville WWTP				X	M	X
Placer Co. SMD #1 WWTP				X	M	X
Proctor & Gamble Co. WWTP					M	X
Red Bluff WWRP					M	X
Redding Clear Creek WWTP					M	X

Table C.23: Potential Requirements Associated with Implementation Alternatives 2 and 3 for NPDES-Permitted Facilities within the Delta/Yolo Bypass and Tributary Watersheds Downstream of Major Dams

	Alternative 2		**Alternative 3**			
Facility	Monitor MeHg & Tot Hg in Effluent & Receiving Water for MeHg Allocation [a]	Participate in Characterization & Control Study	Monitor MeHg & Tot Hg in Effluent & Receiving Water for MeHg Allocation [a]	Participate in Characterization & Control Study	Monitor MeHg in Effluent for Phase 1 MeHg Concentration Limit	Implement TotHg Minimization Program
Redding Stillwater WWTP					M	X
Rio Vista Main WWTP	Q		Q		Q	
Rio Vista Trilogy WWTP / Northwest WWTP	Q	X	Q	X	Q	X
Roseville Dry Creek WWTP					M	X
Roseville Pleasant Grove WWTP					M	X
Sacramento Combined WWTP [b]	Q	X	Q	X	Q	X
San Joaquin Co DPW - Flag City WWTP	Q		Q		Q	
SRCSD Sacramento River WWTP	M	X	M	X	M	X
SRCSD Walnut Grove WWTP (CSD1)	Q		Q		Q	
Stockton (City of) WWTP	M	X	M	X	M	X
Tracy (City of) WWTP	M	X	M	X	M	X
Turlock (City of) WWTP					M	X
UC Davis WWTP					M	X
Vacaville Easterly WWTP					M	X
West Sacramento WWTP	M		M		M	X
Woodland WWTP	M		M		M	X
Yuba City WWTP				X	M	X

(a) Monthly (M) monitoring required for facilities that discharge greater than 1 mgd; quarterly (Q) monitoring required for facilities that discharge less than 1 mgd; no monitoring required if the table cell is blank.
(b) Sacramento Combined WWTP typically discharges as a result of major storm events.

Table C.24: Facilities with NPDES Permit Total Mercury Mass Limits as of December 2007.

Facility	Proximity to the Delta	Flow (MGD)	TotHg Mass Limit in NPDES Permit	Limit Effective Year
Auburn WWTP	Upstream	1.17	0.01 lbs/yr	2005
Brentwood WWTP	Within	3.09	0.083 lbs/yr	2000
Davis (City of) WWTP	Within	5.26	0.038 lbs/month	2007
Defense Logistics Agency Sharpe GW Cleanup	Upstream	1.90	0.042 lbs/yr	2002
El Dorado ID El Dorado Hills WWTP	Upstream	1.08	0.0039 lbs/month	2007
Jackson WWTP	Upstream	0.71	0.0016 lbs/month	2007
Linda Co Water Dist WWTP	Upstream	1.30	0.016 lbs/month	2006
Lodi (City of) White Slough WWTP	Within	4.51	0.113 lbs/month	2007
Manteca (City of) WWTP	Within	4.63	0.69 lbs/yr	2004
Modesto (City of) WWTP	Upstream	7.22	0.7 lbs/yr	2001
Mountain House CSD WWTP-1	Within	(a)	0.005 lbs/month	2007
Placer Co. SMD #1 WWTP	Upstream	1.95	0.00021 lbs/day	2005
Rio Vista Trilogy WWTP / Northwest WWTP	Within	3.00	0.022 lbs/yr	2004
Roseville Dry Creek WWTP	Upstream	13.00	1.71 lbs/yr	2004
Roseville Pleasant Grove WWTP	Upstream	4.82	1.71 lbs/yr	2004
SRCSD Sacramento River WWTP	Within	151.42	5.1 lbs/yr	2001
SRCSD Walnut Grove WWTP (CSD1)	Within	0.08	0.01 lbs/yr	2003
Stockton (City of) WWTP	Within	27.78	0.92 lbs/yr	2002
Tracy (City of) WWTP	Within	9.49	0.042 lbs/month	2007
Vacaville Easterly WWTP	Upstream	9.26	2.1 lbs/yr	2001
West Sacramento WWTP	Within	5.60	0.35 lbs/yr	2003
Woodland WWTP	Within	6.05	1.06 lbs/yr	2005
Yuba City WWTP	Upstream	5.50	0.056 lbs/month	2007

(a) Mountain House CSD WWTP-1 does not yet discharge to surface water.

APPENDIX D
COVER LETTERS TO THE SCIENTIFIC PEER REVIEWERS REGARDING THE JUNE 2006 DRAFT TMDL/BASIN PLAN AMENDMENT STAFF REPORTS

California Regional Water Quality Control Board
Central Valley Region
Robert Schneider, Chair

Linda S. Adams
Secretary for Environmental Protection

Sacramento Main Office
11020 Sun Center Drive #200, Rancho Cordova, California 95670-6114
Phone (916) 464-3291 • FAX (916) 464-4645
http://www.waterboards.ca.gov/centralvalley

Arnold Schwarzenegger
Governor

21 June 2006

Dr. David Sedlak
Department of Civil and Environmental Engineering
657 Davis Hall
University of California
Berkeley, CA 94720-1710

REQUEST FOR REVIEW OF A PROPOSED BASIN PLAN AMENDMENT TO ADDRESS METHYLMERCURY IN THE SACRAMENTO- SAN JOAQUIN DELTA

You have been approved by the University of California, Office of the President, to review a water quality plan to control methylmercury and total mercury in the Sacramento- San Joaquin Delta Estuary (Delta).

Enclosed are the documents to be reviewed, *Amendments to The Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Methylmercury in the Sacramento-San Joaquin Delta Estuary* peer review draft report and appendices to the report. Also enclosed are a summary of the document and a list of major issues we would like to be addressed in the review. Although some issues are identified, we welcome all comments that you might have.

The Regional Board would appreciate receiving comments by **30 August 2006**. If it is not possible for you to return comments by this date, please let me know as soon as possible. We are grateful for your participation in this review and for time spent on the project. If you have any questions now or as you review the document, you may contact me at (916) 464-4621 or email at pmorris@waterboards.ca.gov. You may also contact Michelle Wood at (916) 464-4650 or email at mlwood@waterboards.ca.gov if you have questions on technical details of the report.

Patrick Morris
Senior Water Quality Control Engineer
Mercury TMDL Unit

Enclosures: Peer review draft Basin Plan Amendment staff report
Appendices (includingTMDL Report)
Summary of Basin Plan Amendment
Summary of Technical and Scientific Issues

cc: Gerald Bowes, State Water Resources Control Board

California Regional Water Quality Control Board
Central Valley Region
Robert Schneider, Chair

Linda S. Adams
Secretary for Environmental Protection

Sacramento Main Office
11020 Sun Center Drive #200, Rancho Cordova, California 95670-6114
Phone (916) 464-3291 • FAX (916) 464-4645
http://www.waterboards.ca.gov/centralvalley

Arnold Schwarzenegger
Governor

21 June 2006

Dr. Alexander J. Horne, Professor Emeritus
Department of Civil and Environmental Engineering
Davis Hall, MC 1710
University of California
Berkeley, CA 94720-1710

REQUEST FOR REVIEW OF A PROPOSED BASIN PLAN AMENDMENT TO ADDRESS METHYLMERCURY IN THE SACRAMENTO- SAN JOAQUIN DELTA

You have been approved by the University of California, Office of the President, to review a water quality plan to control methylmercury and total mercury in the Sacramento- San Joaquin Delta Estuary (Delta).

Enclosed are the documents to be reviewed, *Amendments to The Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Methylmercury in the Sacramento-San Joaquin Delta Estuary* peer review draft report and appendices to the report. Also enclosed are a summary of the document and a list of major issues we would like to be addressed in the review. Although some issues are identified, we welcome all comments that you might have.

The Regional Board would appreciate receiving comments by **30 August 2006**. If it is not possible for you to return comments by this date, please let me know as soon as possible. We are grateful for your participation in this review and for time spent on the project. If you have any questions now or as you review the document, you may contact me at (916) 464-4621 or email at pmorris@waterboards.ca.gov. You may also contact Michelle Wood at (916) 464-4650 or email at mlwood@waterboards.ca.gov if you have questions on technical details of the report.

Patrick Morris
Senior Water Quality Control Engineer
Mercury TMDL Unit

Enclosures: Peer review draft Basin Plan Amendment staff report
Appendices (includingTMDL Report)
Summary of Basin Plan Amendment
Summary of Technical and Scientific Issues

cc: Gerald Bowes, State Water Resources Control Board

Attachment 1
Summary of the Basin Plan Amendment

The Central Valley Regional Water Quality Control Board has determined that Delta waterways are impaired due to elevated levels of mercury in fish. To address mercury in the Delta, Central Valley Water Board staff is proposing additions to three Chapters of the Basin Plan: Water Quality Objectives, Implementation, and Surveillance and Monitoring.

A mass balance for methylmercury in the Delta suggests that tributaries contribute more than 60% of Delta methylmercury inputs and that sediment flux from wetlands and open channels contributes about 30%. Other sources of methylmercury include municipal wastewater, urban runoff, and agricultural return flows. Sources of total mercury include tributary inflows, municipal wastewater, atmospheric deposition, and urban runoff. Tributary sources account for about 97% of the total mercury and about 99% of the total suspended solids (TSS) fluxing though the Delta, with more than 80% of the total mercury and TSS loading coming from the Sacramento Basin.

Staff is recommending Delta-specific water quality objectives in terms of concentrations of methylmercury in large, trophic level 3and 4 fish and in small, trophic level 2 and 3 fish. The five alternatives for water quality objectives that were considered and criteria for evaluation are described in the draft Basin Plan Amendment staff report. Derivation of the recommended objectives considers human and wildlife health and follows closely the method used by the USEPA to determine that agency's recommended numeric criterion for methylmercury.

Statistically significant relationships were found between methylmercury concentrations in unfiltered water and fish in the Delta. Staff used the relationships to describe the linkage between methylmercury in water and fish and to determine an aqueous methylmercury concentration "implementation goal" that corresponds to the proposed methylmercury fish tissue objective. By comparing the aqueous methylmercury goal with current concentrations, Staff identified the reductions in methylmercury levels needed to attain the goal and target. Percent reductions in methylmercury concentrations (and loads) required to meet the goal range from 0% for inputs to the Central Delta subregion to more than 70% for inputs to the Yolo Bypass and Marsh Creek subregions.

The proposed Basin Plan amendment presents an implementation plan for reducing aqueous methylmercury loads in the different subregions of the Delta. Essentially, a methylmercury TMDL must be developed for each Delta subregion because the extent of fish impairment, the methylmercury sources, and the percent reductions needed to meet the proposed implementation goal are different in each subregion. The implementation plan includes three components: (1) control methylmercury sources; (2) control total mercury sources; and (3) reduce the public's exposure to methylmercury from fish consumption. Implementation alternatives were evaluated in terms of source type, effort, time to affect change, feasibility, cost and achievement of water quality objectives.

Attachment 2
Summary of Technical and Scientific Issues

The statute mandate for external scientific peer review (Health and Safety Code Section 57004) states that the reviewer's responsibility is to determine "**whether the scientific portion of the proposed rule is based upon sound scientific knowledge, methods and practices**".

We request that you make this determination for each of the following issues that constitute the scientific portion of the proposed regulatory action. An explanatory statement is provided for each issue to focus the review.

1. **The derivation of a linkage between methylmercury in water, largemouth bass and trophic level 4 fish.**

Central Valley Water Board staff used the relationships between length and methylmercury tissue concentration of largemouth bass samples collected in September/October 2000 at multiple Delta locations to estimate methylmercury concentrations in largemouth bass of a standard size (350 mm). Staff described the linkage between methylmercury in Delta water and fish using the regression between the average methylmercury concentration of water sampled between March and October 2000 and the standard 350 mm largemouth bass. The March-October 2000 water data were pooled by Delta subregion to calculate monthly averages. Monthly averages were used to ensure that the March-October 2000 average was not biased by months with different sample sizes. The year 2000 largemouth bass data were used in the linkage analysis because the exposure period of these fish had the greatest overlap with the available water data; monthly water data were collected during the last eight months of the life of the fish.

The regression analysis showed that average concentrations of methylmercury in biota correlate significantly with unfiltered, aqueous methylmercury. This approach is similar to using site-specific bioaccumulation factors (BAF; ratio between methylmercury in fish to water). This analysis is more robust than simple BAFs because there were multiple collection sites within the Delta with varying concentrations of methylmercury in fish.

Staff used the relationship between methylmercury in 150-500 mm TL4 non-migratory fish sampled between 1998 and 2001 and the standard 350 mm largemouth bass to express the proposed TL3 fish tissue objective (0.08 mg/kg) in terms of 350 mm largemouth bass. The resulting largemouth bass "implementation goal" (0.24 mg/kg) was substituted in the water/bass regression equation to determine a corresponding safe level of methylmercury in water (0.066 ng/l). Staff recommends an implementation goal for methylmercury in water of 0.06 ng/l, which incorporates a margin of safety of approximately 18% (margin is greater for some piscivorous wildlife species).

2. Analysis of annual total mercury and suspended sediment loads and conclusions drawn from the analysis.

Water, methylmercury, total mercury and suspended sediment budgets were prepared for the Delta. In addition, water, total mercury and suspended sediment balances were prepared for the Sacramento Basin. For most tributary sources, statistically significant relationships exist between flow and total mercury concentration and/or flow and suspended sediment concentration. For these sources, regression equations were used to predict concentrations that correspond to daily flow volumes. Annual loads were calculated by multiplying the average daily flow by the predicted daily concentration and summing over the year. To estimate annual loads for sources that did not have statistically significant relationships between flow and concentration, the average of available concentration data was multiplied by the annual discharge.

Staff is in the process of calculating the 95% confidence intervals for the total mercury and suspended sediment load estimates and for the Delta and Sacramento Basin mass budgets. The confidence intervals will allow staff to determine whether the Delta and Sacramento Basin total mercury and sediment budgets “balance” (i.e., whether there is a statistically significant difference between the inputs and exports). Staff expects to provide the confidence interval calculations and conclusions drawn from them to the peer reviewers in an addendum by 21 July 2006. The confidence interval information that will be revised is in Sections 7.1.1, 7.2, 7.3, and Appendix J of the TMDL Report.

3. Effectiveness of proposed implementation actions in achieving the desired reductions in methylmercury in ambient water and fish tissue.

Methylmercury production is affected by multiple factors, including concentrations of available mercury in sediment, sulfate, nutrients, pH of overlying water, and degree of anoxia. The proposed implementation plan addresses factors that affect methylation. One example is the proposed requirement that new water impoundments or wetlands projects produce no net increases in methylmercury loads. In addition, the proposed implementation plan recommends reducing total mercury loads entering the Delta, which is expected to result in decreases of methylmercury production. Also during implementation, Staff will incorporate new information about controlling methylation and demethylation in the Delta and its tributary watersheds.

4. Overarching questions.

Reviewers are not limited to addressing only the specific issues presented above. Additionally, we invite you to contemplate the following “big picture” questions.

(a) In reading the staff technical reports and proposed implementation language, are there any additional scientific issues that are part of the scientific portion of the proposed rule not described above? If so, please make the determination defined above from the statute language.

(b) Taken as a whole, is the scientific portion of the proposed rule based upon sound scientific knowledge, methods, and practices?

The preceding guidance will ensure that reviewers have an opportunity to comment on all aspects of the scientific basis of the proposed Regional Board action. At the same time, reviewers also should recognize that we have a legal obligation to consider and respond to all feedback on the scientific portions of the proposed rule. Because of this obligation, we encourage you to focus your feedback on the scientific issues that are relevant to the central regulatory elements being proposed.

California Regional Water Quality Control Board
Central Valley Region
Robert Schneider, Chair

Linda S. Adams
Secretary for Environmental Protection

Sacramento Main Office
11020 Sun Center Drive #200, Rancho Cordova, California 95670-6114
Phone (916) 464-3291 • FAX (916) 464-4645
http://www.waterboards.ca.gov/centralvalley

Arnold Schwarzenegger
Governor

26 July 2006

Dr. Alexander J. Horne, Professor Emeritus
Department of Civil and Environmental Engineering
Davis Hall, MC 1710
University of California
Berkeley, CA 94720-1710

ADDENDUMS TO THE SACRAMENTO – SAN JOAQUIN DELTA METHYLMERCURY TMDL DRAFT REPORT

Please find attached two addendums for the Sacramento-San Joaquin Delta TMDL draft report. As mentioned in our June 2006 request for review (Attachment 2, Section 2), staff completed the calculation of the 95% confidence intervals for the total mercury and suspended sediment load estimates and for the Delta and Sacramento Basin mass budgets. The purpose of the confidence intervals is to allow staff to determine whether the Delta and Sacramento Basin total mercury and sediment budgets "balance" (i.e., whether there is a statistically significant difference between the inputs and exports), and to formulate recommendations for compliance with the San Francisco Bay mercury TMDL allocation for the Delta. The confidence interval information and related text was revised throughout Chapter 7 and Appendix J of the TMDL Report. These report sections should be completely replaced by the attached addendums. In addition, Appendices L and M (compilations of all fish and water mercury concentration data in Microsoft Excel files) are available upon request.

We look forward to receiving your comments. If it is not possible for you to return comments by 30 August 2006, please let me know as soon as possible. We are grateful for your participation in this review. If you have any questions as you review the documents, you may contact me at (916) 464-4621 or email at pmorris@waterboards.ca.gov. You may also contact Michelle Wood at (916) 464-4650 or email at mlwood@waterboards.ca.gov if you have questions on technical details of the report.

Patrick Morris
Senior Water Quality Control Engineer
Mercury TMDL Unit

Enclosures: Chapter 7 (TMDL Report)
Appendix J (TMDL Report)

cc: Gerald Bowes, State Water Resources Control Board

California Regional Water Quality Control Board
Central Valley Region
Robert Schneider, Chair

Linda S. Adams
Secretary for Environmental Protection

Sacramento Main Office
11020 Sun Center Drive #200, Rancho Cordova, California 95670-6114
Phone (916) 464-3291 • FAX (916) 464-4645
http://www.waterboards.ca.gov/centralvalley

Arnold Schwarzenegger
Governor

26 July 2006

Dr. David Sedlak
Department of Civil and Environmental Engineering
657 Davis Hall
University of California
Berkeley, CA 94720-1710

ADDENDUMS TO THE SACRAMENTO – SAN JOAQUIN DELTA METHYLMERCURY TMDL DRAFT REPORT

Please find attached two addendums for the Sacramento-San Joaquin Delta TMDL draft report. As mentioned in our June 2006 request for review (Attachment 2, Section 2), staff completed the calculation of the 95% confidence intervals for the total mercury and suspended sediment load estimates and for the Delta and Sacramento Basin mass budgets. The purpose of the confidence intervals is to allow staff to determine whether the Delta and Sacramento Basin total mercury and sediment budgets "balance" (i.e., whether there is a statistically significant difference between the inputs and exports), and to formulate recommendations for compliance with the San Francisco Bay mercury TMDL allocation for the Delta. The confidence interval information and related text was revised throughout Chapter 7 and Appendix J of the TMDL Report. These report sections should be completely replaced by the attached addendums. In addition, Appendices L and M (compilations of all fish and water mercury concentration data in Microsoft Excel files) are available upon request.

We look forward to receiving your comments. If it is not possible for you to return comments by 30 August 2006, please let me know as soon as possible. We are grateful for your participation in this review. If you have any questions as you review the documents, you may contact me at (916) 464-4621 or email at pmorris@waterboards.ca.gov. You may also contact Michelle Wood at (916) 464-4650 or email at mlwood@waterboards.ca.gov if you have questions on technical details of the report.

Patrick Morris
Senior Water Quality Control Engineer
Mercury TMDL Unit

Enclosures: Chapter 7 (TMDL Report)
Appendix J (TMDL Report)

cc: Gerald Bowes, State Water Resources Control Board

APPENDIX E
SCIENTIFIC PEER REVIEW COMMENTS ON THE DRAFT TMDL/BASIN PLAN AMENDMENT REPORTS PROVIDED IN AUGUST AND SEPTEMBER 2006

UNIVERSITY OF CALIFORNIA, BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

ENVIRONMENTAL ENGINEERING PROGRAM
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
631 DAVIS HALL #1710
BERKELEY, CALIFORNIA 94720-1710

PHONE: (510) 642-4011
FAX (510) 642-7483

August 8, 2006

BY ELECTRONIC MAIL
Patrick Morris
Senior Water Quality Control Engineer
California Regional Water Quality Control Board
Central Valley Region
11020 Sun Center Drive #200
Rancho Cordova, CA 95670-6114

Dear Mr. Morris:

I am writing in response to your request of June 21, 2006 to provide a peer review of the Amendment to the Basin Plan and TMDL for mercury in the Sacramento-San Joaquin Delta (the Delta). I have reviewed the documents provided as well as other materials related to the project and have evaluated the scientific basis for the proposed actions. My comments are listed below:

1. General Impressions

The proposed basin plan amendments and supporting TMDL describe an approach for addressing the elevated concentrations of mercury in the Delta. The approach also addresses the mass of mercury released from the Delta because control of the export of mercury from the Central Valley is integral to the proposed San Francisco Bay TMDL. The general approach of the TMDL is to control methylmercury by reducing methylmercury concentrations in wastewater effluent and the mass of inorganic mercury released to the Delta from upstream sources. Given the complexity of the problem and the difficulties associated with setting goals that are achievable, I believe that the staff members have used the available scientific data in a reasonable manner. Although I have some concerns about specific details, I have not found any major flaws that would call the scientific approach into question.

2. Total Mercury Control Actions (Page ES-4; BPA 3-4)

The Executive Summary includes a statement that NPDES-permitted WWTPs must implement a pollution control plan for total mercury. No scientific evidence is presented in the report that supports the idea that these programs will have a measurable impact on methylmercury released from WWTPs. According to the TMDL, methylmercury is the main concern at WWTPs and inorganic mercury is much less of an issue because concerns associated with releases to San Francisco Bay are related to particle-associated mercury and not dissolved inorganic mercury (i.e., WWTPs don't discharge high TSS loads). The science presented in the report supports the idea of finding ways to minimize methylmercury formation in WWTPs but the data in the appendix (e.g., Figure G.2) do not support the idea that there is a relationship between either influent inorganic mercury or methylmercury and effluent methylmercury concentrations. Although no data are presented on total mercury in wastewater influent and effluent, I suspect that source reduction will have little or no effect on effluent total mercury concentrations. The main benefit of source control would probably be a decrease in mercury concentrations in sludge produced by the wastewater treatment plants. While there are benefits associated with lowering mercury concentrations in sludge, it would be hard to justify such benefits as part of the Delta TMDL process.

3. Possible error in Table B (page BPA-12)
Is the percent reduction for the W. Sacramento WWTP supposed to be 0% and not 100%?

4. Beneficial uses: impairment of municipal and domestic supply (p. 15 of staff report and p. 133 of TMDL)
I recognize that the CTR specifies a standard of 50 ng/L for a 30-day running average mercury concentration in water and I agree with the staff analysis of the 30-day running averages. Therefore, from a legal standpoint the CTR is violated. However, I believe that the staff report should discuss the fact that the elevated inorganic mercury concentrations are attributable to the high TSS during high flow events and that the suspended solids would be removed during conventional water treatment. My impression is that the CTR mercury value was developed to protect humans from exposure to mercury through consumption of fish and to prevent high concentrations of dissolved mercury from being delivered in tap water. Although the CTR may be violated from a legal standpoint, there is no scientific evidence that potable water supply is threatened by mercury. (Ultimately, this is not an important issue because the proposed activities probably would bring the Delta into compliance with respect to the 50 ng/L value. However, I think the document implies that municipal water supplies in the Delta are unsafe because of mercury and such a conclusion is not supported by the available science.)

5. Correlations between LMB MeHg concentration and TL4 Fish MeHg concentrations (Staff report p. 27 and TMDL page 54)
To convert MeHg concentrations in a TL4 150-500 mm fish to a LMB MeHg concentration a linear regression model is used. As stated in the footnote on page 53, the regression equation was forced through the origin. The other curves used a logarithmic relationship with no constraints on the data. Given the fact that these are empirical fits there is no basis for forcing this one regression through the origin and not imposing similar constraints on the other relationships. (I realize that you cannot fit log-transformed data through the origin.) If there is no basis for forcing the fit through the origin, a simple linear regression should be used, which might yield a slightly lower value for the LMB MeHg concentration.

6. Apparent disconnect for snowy plover (TMDL page p. 33, Table 4.2 and p. 47, section 4.7.2)
In table 4.2 it appears that the safe dietary concentration of methylmercury is 0.026 mg/kg. However, in section 4.7.2 the snowy plover value is 1.12 mg/kg. I believe that this is related to the fact that most of the snowy plover's diet consists of aquatic and terrestrial invertebrates. However, it is unclear if any assumptions have been made about MeHg concentrations from this portion of the snowy plover's diet.

7. Example calculation (TMDL p. 36)
For clarity, I suggest you show more than one significant figure on the example calculations.

8. Missing reference (TMDL p. 50)
Davis and Greenfield (2002) is not included in the reference list.

9. Municipal and industrial sources of MeHg (TMDL p. 76)
The analysis of municipal and industrial sources of MeHg ultimately results in the decision that WWTPs in sub-regions where the MeHg concentrations are too high will have to reduce their concentrations to values as low as 0.06 ng/L. However, other industrial users are not subject to the same restrictions because a comparison of intake and outflow data suggests that they are not increasing MeHg concentrations through their processes. What about a wastewater treatment plant for a community that takes its potable water from a Delta tributary? Many of the tributaries have between 0.1-0.3 ng/L of MeHg (e.g., Figure 6.3). Because the raw water used by the community could contain more MeHg than the effluent from the same community's WWTP, by the logic used here, the community should be given credit for removing MeHg from the tributary water rather than penalizing the community for their WWTP discharge. The approach used in the TMDL should treat the industrial and municipal dischargers in a similar manner.

10. Mercury runoff coefficients (TMDL p. 122)
I understand why mercury may be transported less easily than water when it comes in contact with land surfaces but the possibility that it could be more easily transported does not make a lot of sense to me. Is this a misstatement or can more explanation be provided here?

11. Table headings (TMDL p. 145-149)
I believe that the Table heading has an error: "Acceptable MeHg Concentration" should be in units of ng/L and not g/yr.

12. "Statistically Significant Regressions" (TMDL J-17)
The conclusion that all of these regressions are significant is questionable. For example, the Feather River graph shows about 30 data points with flows less than 30,000 cfs and three with higher flows. Without the three higher points I suspect that there would not be a significant relationship (i.e., it would look like a scatter plot). Simple linear regression models assume equal spacing of data and these regressions may be biased by a few high flow observations. It may be necessary to consult a statistician about the need to weigh

the data to avoid bias or to identify other ways to test the significance of putative relationships.

Sincerely,

David L. Sedlak
Professor

cc: Professor David Jenkins

California Regional Water Quality Control Board
Central Valley Region
Robert Schneider, Chair

Linda S. Adams
Secretary for Environmental Protection

Sacramento Main Office
11020 Sun Center Drive #200, Rancho Cordova, California 95670-6114
Phone (916) 464-3291 • FAX (916) 464-4645
http://www.waterboards.ca.gov/centralvalley

Arnold Schwarzenegger
Governor

30 August 2006

Dr. David Sedlak
Department of Civil and Environmental Engineering
657 Davis Hall
University of California
Berkeley, CA 94720-1710

CLARIFICATION OF SCIENTIFIC REVIEW COMMENTS ON THE DRAFT DELTA METHYLMERCURY BASIN PLAN AMENDMENT

Thank you very much for your scientific review comments that you provided on 8 August 2006. We sincerely appreciate your careful consideration of the draft staff report, "*Amendments for the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Methylmercury in the Sacramento- San Joaquin Delta Estuary*" and supporting document, the *Delta TMDL for Methylmercury Report*. We will consider your comments in a revised draft Basin Plan Amendment and staff report.

We would appreciate if you could elaborate on your response to one issue. In the peer review request letter, you were asked to "…determine "whether the scientific portion of the proposed rule is based upon sound scientific knowledge, methods and practices". In Attachment 2 of the peer review request letter, we highlighted three scientific issues from the draft Delta methylmercury Basin Plan Amendment for such a determination. The third issue was the, **"Effectiveness of proposed implementation actions in achieving the desired reductions in methylmercury in ambient water and fish tissue."**

In your letter, you commented on the potential effectiveness of controlling sources of total mercury and methylmercury from municipal and industrial facilities. Could you please comment on whether your understanding of the science supports other parts of the proposed methylmercury control program, including the proposal to require studies to further characterize loads and develop control practices for methylmercury from managed wetlands, agricultural sources, and urban runoff? For existing discharges in these categories, the proposed Basin Plan Amendment only requires characterization and control studies. At the end of the study period (2014), the Central Valley Water Board would evaluate the results and determine whether some or all of the methylmercury sources would be required to implement management practices to reduce methylmercury.

For your reference, staff's reasons for addressing methylmercury sources (instead of just sources of inorganic mercury) are on page 31 of the draft Basin Plan Amendment Staff Report and description of a Delta study that showed differences in methylmercury productions in adjacent wetlands with different design characteristics is on page 57. A description of options for actions addressing nonpoint sources of methylmercury begins on page 75.

Thank you very much for your time and willingness to add to your original response. If you have questions, you may contact me at (916) 464-4621 or email at pmorris@waterboards.ca.gov. You may also contact Janis Cooke at (916) 464-4672 or email at jcooke@waterboards.ca.gov.

Patrick Morris
Senior Water Quality Control Engineer
Mercury TMDL Unit

cc: Gerald Bowes, State Water Resources Control Board

UNIVERSITY OF CALIFORNIA, BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

ENVIRONMENTAL ENGINEERING PROGRAM
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
631 DAVIS HALL #1710
BERKELEY, CALIFORNIA 94720-1710

PHONE: (510) 642-4011
FAX (510) 642-7483

September 6, 2006

BY ELECTRONIC MAIL
Patrick Morris
Senior Water Quality Control Engineer
California Regional Water Quality Control Board
Central Valley Region
11020 Sun Center Drive #200
Rancho Cordova, CA 95670-6114

Dear Mr. Morris:

I am writing in response to your request of August 30, 2006 to provide additional information on my peer review of the draft water quality control plan for methylmercury in the Sacramento-San Joaquin Delta. Specifically, you asked me to elaborate on the scientific validity of the proposal to require studies to further characterize methylmercury loads and to develop control practices for methylmercury from managed wetlands, agricultural runoff and urban runoff.

I did not comment on these approaches specifically in the review that I sent to you on August 8 because I interpreted my charge to be related to only the scientific portion of the review and I interpreted the approach of waiting until additional research was completed as a policy decision. However, upon reflection I agree with you there are some scientific issues underlying this approach that are appropriate for me to include in my review. In the following paragraphs I have summarized some of my thoughts on these issues.

The first scientific question is related to whether available data can be used to accurately determine the contributions of methylmercury from managed wetlands, agricultural runoff and urban runoff. The staff members have attempted to quantify these sources in the draft plan. The estimates of loading from these three classes of methylmercury sources are based on a very limited data set and have considerable uncertainty. Therefore, I agree with the staff's decision to require the collection of additional data to obtain better estimates of the loading from non-point sources. The approach for obtaining additional data is not described in detail, so I am unable to assess the likelihood that the data collected during the study period will establish precise methylmercury load estimaes. Data on methylmercury fluxes from these diverse sources are likely to be difficult to obtain and I expect that there still will be uncertainity in the estimates after additional data collection. To increase the likelihood that the data will be useful to future load estimates I suggest that any additional plans for data collection be subjected to peer review.

The second question is related to whether or not there are adequate data to assess the costs and efficacy of various control options. The decision to regulate methylmercury loads from these three types of sources sets new precedent and there is not a lot of experience on how to accomplish this objective. I agree with the staff that there currently is not enough information to design effective control strategies or to estimate the costs of such strategies. For example, the staff reports on the first year of a Calfed study indicating different mercury methylation rates from test wetland cells. One year of unpublished data from one site is not sufficient for drawing conclusions about the likelihood of success or costs of larger restoration projects. At this point, it is difficult to know if methylmercury production really can be minimized by wetland designs. About all that can be said at this point is that wetlands probably make more methylmercury than unrestored land. Without additional research, it seems likely that the only control strategy for methylmercury in restored wetlands would be not to restore wetlands. If this is the effect of requiring that restored wetlands do not increase methylmercury loadings, I believe that this decision should be made in light of the benefits to the ecosystem associated with habitat restoration.

Similar issues are likely to be encountered in association with agricultural runoff and stormwater runoff. I agree with the staff that the planned collection of data on methylmercury concentrations in agricultural drains and runoff will be useful to establishing a mas balance. However, I am uncertain that cost-effective approaches for reducing methylmercury concentrations will be developed during the study period. It is likely that any approaches that are developed will be limited to specific types of soils and crops, thereby necessitating site-specific studies prior to selection of control approaches. Likewise, quantification of mercury and methylmercury in stormwater is likely to be challenging due to the potential for sample contamination and the variability of flows within storms.

In conclusion, I believe that the staff has employed a sound approach to implementing the TMDL in a stepwise fashion that is consistent with the principles of adaptive management, which was recommended by the National Academies in their review of the TMDL process. After completion of the planned studies it is likely that the staff will be in a better position to assess methylmercury loading and the costs associated with control activities. However, the estimates of methylmercury loads from these sources and the cost-effectiveness of various control strategies will always have considerable uncertainty.

Sincerely,

David L. Sedlak
Professor

Memo to: Patrick Morris, Senior Water Control Engineer Mercury TMDL Unit, Regional Water Quality Control Board, Central Valley Region
From: Professor Alex Horne (UC Berkeley), Reviewer
Re: Addendums to the Sacramento-San Joaquin Methymercury TMDL Draft Report
Date: 1 September 2006

SUMMARY
The Regional Board's staff and their contract research workers have done much good work on methylmercury (MeHg) in the Delta and the addendums and TMDL documents themselves contain much valuable information based on sound science. However, given the unusual chemistry of mercury and the special wetland ecology of the Delta it is likely that the proposed solutions will cause more harm than good. There are five scientific concerns: loss of Delta habitat, arbitrary decisions, unclear mass balances, unethical scientific practices, and fossilized standards. The main instructions given to reviewers are not appropriate. They request the reviewer to give detailed amendments to specific sections assumes that the reviewer accepts the initial findings from which all the details are spawned. Unfortunately, in the special case of MeHg, this assumption is not met. However, the instructions to the reviewer do contain a request for any "over-arching concerns". These are included below and are most important in the way the proposed MeHg standards will restrict the restoration of the Delta and its wildlife. The solution to the impasse may not be soluble under existing rules and will require the Board to define a new paradigm for pollution trading. Thus my only option is to find that the "No Action" alternative is the only way to save the biota of the Delta. A provision to reduce total mercury from the Cache Creek area and in mountain stream is an imperative that should not be affected by this no action alternative.

1. Loss of Delta habitat. The overriding ecological need in the Delta is to restore as much habitat as possible to its original tidal wetland state. A minimum of 300,000 acres of restored wetland are needed since about 850,000 were lost. All other concerns are relatively minor. Although the restoration of the Delta is not the Board's main responsibility, in its MeHg TMDL addendums proposal the single-minded pursuit of mercury control threatens Delta restoration. In effect the TMDL will throw the baby (the Delta) out with the bathwater (excess MeHg). Some Delta wetlands produce MeHg from inorganic Hg entering from the Coast Range and Sierra streams and also from aerial deposition. Since these sources are unlikely to be reduced very much in the next 50 years, large amounts of this Hg will be converted to MeHg at levels in excess of the proposed standards. Thus restoration of wetlands in the Delta is effectively prevented since unattainably large MeHg offsets will be needed. This point is well known to the Board staff (e. g. section 3.5 and key points on p. 26 of the TMDL documents). However, the Board does not guarantee that such offsets will be available in anything like the quantity needed and indeed, indicates that they may not be available.

The obvious scientific solution is to balance the potential harm of MeHg production in wetlands with the certain large ecological benefit of these wetlands. However, the Board lacks the trading machinery to offset high levels of mercury with anything but decreases in the same element elsewhere. Urgently needed is a trade (offset) between wetlands restoration benefits and MeHg production. Currently the

Board only offsets like with like (i. e. Hg with Hg) not mercury with, for example, increase in habitat area. It is not sound science to restrict the certain benefits of restoration of the Delta for possible harm caused by low levels of MeHg. This argument applies with even more force to endangered wildlife where the supposition of harm from MeHg may result in the loss of the habitat which would allow the full recovery of the species.

2. Arbitrary decisions. Not enough is understood about the environmental chemistry of mercury in the Delta to make informed scientific decisions (for example what controls MeHg in wetlands). The Board's staff is very aware of the uncertainties about the synthesis of MeHg in the Delta occurs in wetlands. In the documents provided it is thought that sulfur may be involved. In the work of my own group at UC Berkeley we have found that iron and redox are also important (these factors are not considered in the TMDL documents provided suggesting 3b errors and incomplete rather than unsound science). Overall, the thermodynamics of the production of MeHg dictate that very low redox potential (and thus the kind of plants in the wetland) is important. My view is that making detailed plans for allocations of MeHg loading are thus premature until more is known about how to construct large seasonal and permanent wetlands that do not produce very much MeHg. More logical at this time would be an attack on the known main sources that are understood (old mines, sediment from these mines, other external sources) since the chemistry and hydraulics of these large sources is known. The Board's comments that much Hg in river sediments is essentially uncontrollable contrasts with the Board's certainty that other equally difficult sources can be controlled or offset.

3. Mass balance concerns. The main strategy of the board for all but the smallest entities is to offset any their MeHg in other Delta areas. This provision becomes important for large uncontrolled wetlands such as the current main in-Delta source, the Yolo Bypass wetlands. As more such large wetlands are restored in the Delta is not clear is there is sufficient offset available. For example, the Board's documents are vague in indicating the offset value of the Cache Creek Settling Basin in comparison with the detail of the amounts of MeHg allowed by each discharger in each site. Are there enough MeHg (or Hg) offsets in the Delta to allow its restoration? If non-similar offsets were allowed as indicated above then this question would go away.

4. Unethical Scientific Practices. Although sounding rather grim, unethical scientific practices are common flaws and normally easily corrected. In any large work such as that carried out by the Board's staff or similar reports that I have written, a few unethical scientific practices tend to seep in here and there. All scientists are potentially guilty of such lapses and there are accepted rules to correct them. The prime errors are classified as (i) Positive Operator Bias (POB) which is usually an unconscious selection of non-representative data (usually a extreme high or low) and (ii) 3b errors commonly thought of as errors of omission or "cherry-picking" of available data. Because many of us, including the Board's staff are keen environmentalists, these two errors are hard for the writer to keep out even as they are obvious to the reviewer.

In this report the usual POBs occurred in terms of always choosing the most conservative value rather than a mean or representative values. Good science requires use of the representative means. A safety factor which is usually not based on science can then be added at the end if conservative values are needed for political reasons. Thought it seems good to use extreme values, the use of low or high estimates at all stages of the calculations can result in “silly” high or low standards. In almost all cases the Central Valley Regional Board’s staff has followed this method in the TMDL and water quality addendum documents reviewed here. However, in some cases this method has not been followed. For example the assumption that 100% Hg in fish is MeHg for purposes of monitoring rather than the average of 85-100% (~ 93%?) as was found in the data is one example of POB. The 3b errors are harder to detect but the mitigating effects of Se on MeHg toxicity and the lack of evidence of MeHg toxic effects in currently high MeHg areas are two examples. Se is abundant in the south delta and is well known as a natural or accidental antidote to Hg toxicity (much work has been carried out on European raptors). Other examples are shown in the main text of my comments.

The main unethical problems do not appear to be in the work of the Board’s staff but in the work on which they have relied, especially the mercury toxicity studies of the USFWS (the key to the entire Board calculations appears to be a study on mink and mercury carried out by the USFWS to establish a base line for mercury concentrations vs. health effects). I have not reviewed this secondary work here since it was not in the mandate. However, in my reviews of this agency’s work in the past I have found that the USFWS does not have a policy to remove POBs and type 3b errors which are thus often rife. In some cases the toxicity studies are set up so that the LC50 or similar measure is lower than would normally occur using sound science. While we all want a measure of safety in our toxicity predictions, the safety factor should be added on a the end not within the experiment. Thus their work (in this small area at least is not sound science, though the intentions are good; I cannot comment on other responsibilities of the USFWS). It is not my place here to have the Regional Board staff judge the quality of the work of a federal agency but if this work could be validated by a more reliable independent non-agency study I would feel more comfortable about the compromises that would be made if a lower Hg standard was applied in the Delta.

5. Fossilized standards. The report is written as if future flexibility can occur in standards. This is not likely and has become a huge flaw in the scientific part of the standard setting mechanism in California and the US as a whole. The proposed MeHg standard in water as suggested in the report is based on the Regional Board staff (and other’s) excellent and extensive field work on fish and water and some nice science-based regressions. Nevertheless the addendum recommendations are somewhat arbitrary. The #4 option chosen still does not protect human Delta residents who consume large amounts of some locally-caught fish. The rare bird consumption values are inflated by not considering feeding outside the Delta and may bias the resulting standard. The proposed standard may also be artificially low since it is based on a USFWS toxicity study. Why not chose the less protective options #3 or #4 and then change these as experience and more information become available? There are also numerous smaller decisions in the report that are best justified as “as good as we can do with the existing information.” Such compromises are inevitable but experience has taught us that it is virtually impossible to modify standards or Basin Plan Objectives, even if the future scientific evidence is overwhelmingly in favor of changes. The case of the regulation of copper in San Francisco Bay shows that the poor chemical understanding of copper chemistry by regulators in the 1970s was maintained for over 25 years in the face of a huge mass of more scientific evidence. Millions of dollars were wasted in protecting the wrong thing. Will this happen with MeHg in the Delta? Will the even less well understood chemistry of MeHg remain in statutes for similar periods? The emphasis on the wrong toxicant or form of toxicant has considerable ecological costs since funds wasted could be spent on real toxicity problems or habitat improvements.

A NEW PARADIGM FOR POLLUTANT TRADING

As discussed briefly above in item #1, I am concerned that focusing single-mindedly on MeHg, the restoration of the Delta will be constrained or prevented. The situation is unique to heavy metals with an actively metabolized organic fraction and districts with extensive wetlands. Thus my concern so may be confined to mercury, selenium and perhaps arsenic and Central Valley regions. Thus other TMDLs' on which this mercury TMDL is based may not be fully appropriate templates.

In my opinion the only sound scientific way to achieve the Board's objectives is to use some other currency for offsets. For example, the Yolo Bypass and other wetlands to be created to restore the original Delta are a large environmental good. Farms also are a social good. Both wetlands and farms may increase MeHg. To remove these wetlands or farms or require them to pay for mercury cleanup upstream is bad for the Delta. The Board must use science to balance the good of wetlands or farms against the harm of MeHg production. Perhaps, as the report indicates, wetlands and farms can be managed to produce less MeHg. However, a preliminary finding on this topic dated June 2006 obviously was not the driving force of the Board's TMDL written earlier.

I have suggested a new trading paradigm before. In the Santa Ana Region the case of Lake Elsinore is an example. In this case I suggested a swap of N & P for lake water level. This lake in a very dry area sometimes dries up and is often very shallow which degrades water quality and impairs beneficial uses. The Santa Ana Regional Board has been adventurous in allowing the use of reclaimed water containing nutrients to be used to provide makeup water for Lake Elsinore. However, this regional board also required pound for pound N and P offsets for the nutrients added along with the water. I calculated that the benefits of an increased foot of water were about $2.3 million/yr. The costs of providing offsets conventionally can be high (especially at lower N & P levels in wastewater where nutrients have been removed to quite low levels). Thus much of the benefit of the higher water level was consumed by increased water and in-lake treatments. Thus there is a considerable impediment to improving Lake Elsinore because trading in N & P can only be for other N & P offsets. If N & P additions were traded for water elevation increases then a more logical trade would occur. Similarly trading MeHg for other benefits such as increased wildlife habitat area seems to be a vital ingredient in the Delta region.

DETAILED COMMENTS

Once a standard of MeHg was decided, the vast bulk of the report is good since most conclusions follow from the initial decision. I will analyze the key item; the five alternatives in the section 3 (Water Quality Objectives) of the Amendments document. Here the driving focus is "All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in humans, plant, animal or aquatic life." The criterion used is the CRT criterion of 50 ng/L total recoverable Hg in the water column (this criterion is not exceeded anywhere in the Delta except downstream of the Cache Creek settling basin and a couple of other sites according to the TMDL document, pg 18). These two definitions do not produce the numerical objectives specified later in the document but these numerical objectives are needed by the Board to determine progress in attaining the beneficial uses.

COMMENT. The option #4 is chosen. As described elsewhere any option that reduces the likelihood of the re-creation of tidal and other wetlands in the Delta is self defeating. The wildlife may be totally free of possibly toxic MeHg, but that will not matter. There will be no wildlife to save. The reality is that several million of the 20 million more Californians that will be in the state in 2050 will live in and around the Delta. Without a lot of larger new wetlands the wildlife will vanish. Thus the MeHg standard should take note of the changed environment. As also stated elsewhere this problem is more or less unique to the case of mercury and the Delta region and so other Regional Boards may not face such a trade off.
SUGGESTION. Go with the No Action alternative at this time with provisions to reduce the Cache Creek and upstream mercury. Intensify research on how to run wetlands to give lower MeHg outputs (consider redox as the master variable here). When that question is solved then many sections of the current reports may be appropriate.

COMMENT. Anoxia (Redox) in the sediments as a cause of methylation. I was surprised that the oxygen level or more precisely anoxia, was not considered in the five conditions controlling MgHg production in the TMDL documement (pg. 20). Since the addition of oxygen even at levels of 0.1 mg/L is an experimentally demonstrated method to prevent methylation it is obviously of concern in the Delta. It is also a potentially controllable situation in some areas including wetlands that are so important in in-Delta MeHg production. Oxygenation of water is a simple and inexpensive process and can be increased in wetlands by the choice of plants and hydroperiod.
SUGGESTION. Add the role of oxygen and low redox to the appropriate section and consider solutions to methylation in Delta habitats at risk. Low redox is not normally needed for Delta wetlands which will denitrify waste nitrate and grow insect food for birds and fish without methylating mercury.

COMMENT. Piscivorous fish are assumed to obtain all of their fish or other aquatic prey from the local water body so no relative source contributions (RSC) are used (TMDL document p 29). Unless I have misunderstood the sense or the report, this is an example of both POB and possible 3b ethical error. The POB is obvious in that most birds move or migrate over days and seasonally. Thus they may feed on MeHg contaminated food on one day (week) and uncontaminated food on the next. This kind of migration bedevils field toxicity studies but must nonetheless be accounted for. Thus the bias gives a much higher accumulation number than the likely true value. Feeding patterns of most birds are well known but only those for rare birds drive this consideration. For example, the three threatened birds listed in the report (p. 30) include the least tern which is reported to winter south of the USA suggesting that using the correct RSC would considerably lower the amount of lifetime MeHg that they consumed. The two other threatened species mentioned, bald eagles & peregrine falcons also migrate considerable distances and the falcons do not eat much fish. I am aware that the consideration of threatened birds includes the notion that all individuals not just the population be considered. However, this is not a scientific notion and thus is not sound science. In addition the Endangered Species Act suggests that the habitat and its species are more important than preservation of individuals (the "no-zoo" approach).

The possible 3b error is that these feeding studies are very likely to be available elsewhere suggesting cherry picking of the data to support lower Hg standards than scientifically justified.

SUGGESTION. Determine and use the correct RSC MeHg input and diet for the rare species involved. Use this to correct the level of MeHg needed in to protect threatened species to a higher level (if appropriate).

COMMENT. USFWS guidance to the Regional Board on exposure parameters. This reviewer is not privy to these guidance parameters but past experience with the USFWS in the Central Valley indicates that POB and type 3b errors are common in USFWS reports. Sound science cannot operate in these opaque conditions.

SUGGESTION. However, the Board's staff could review USFWS advice, compare it with unbiased information, and ensure that POB and type 3b errors do not unduly change their MeHg standards.

COMMENT. Dilution of MeHg with increased biomass. In a recent MeHg project in which I was involved in New York (Lake Onondaga), the restoration of the biota was considered to dilute the available MeHg. The situation is the same in the Delta. The Hg inputs are constant or declining. Thus if more wetlands and more wetlands biota are created the MeHg/individual will decline. In addition, some Hg may be stored permanently in the deeper sediments of the wetlands where it is biologically unavailable.

SUGGESTION. Calculate the dilution and use the factor obtained to monitor the biota to determine if the proposed standards can be lessened.

A PERSONAL COMMENT ON MERCURY TOXICITY

I have had personal and professional experience with the horrors of organic mercury. As a high school boy in England I sometimes had to help my senior chemistry teacher who had experimented with organic mercury in his undergraduate days before the First World War. His shaking hands and permanent pain were a shock to me and a reminder of the damage of chemicals even before Rachael Carson's "Silent Spring." Of course mercury's dangers were not well known then and his nervous system had been damaged for life. As a teenager I had the harrowing experience of nursing wild birds during the grotesque dance and convulsions they undergo before dying of mercury poisoning from eating seeds on farmland coated with organic-Hg. Finally, as a teacher I taught that the Minamata tragedy in Japan that was due to careless and prolonged releases of large quantities of mercuric acetate to the ocean close to fishing grounds. Jan Ui's book on this topic was particularly revealing (Ui, Industrial Pollution in Japan, 1992, Chapter 4). These were not pleasant experiences and I fully support reduction of mercury and especially organic mercury in the environment.

However, the situation in the Delta is not that of early 20th century scientists, or the 1950s industrial and farmland releases and uses of mercuric acetate. The Delta's case is altogether less serious and the sources more tenuous and less controllable (at present). The Board's report indicates that many cleanups (e. g. new wetlands) will not begin seriously in 2014 and that the overall major source cleanups may take hundreds of years to work. And even then human health is not fully protected. The proposed numerical MeHg solutions look as thought they could prevent the restoration of the Delta wetlands and thus destroy the wildlife resource they seek to protect. Something is wrong.

NOTE ON ERROR TERMINOLOGY

The POB or Positive Operator Bias is more or less self explanatory. We all make unconscious choices even when trying to be fair. The common example used is to ask students to take toothpicks from a pile but not to select any one size. After the choices is it usually found that they unconsciously select the largest. In scientific work there is often a choice of which number to use. Bias then can slip in. Since the selection is usually to support the hypothesis of the worker the bias is usually positive or in favor the hypothesis. In his case the POB will be to be more protective of wildlife and humans from MeHg toxicity than strictly merited by the science.
Type 3b errors. This term comes from a concern about sound science from the US Congress in the 1990s. It will be remembered that some disputed scientific findings made headlines (possible falsification of data on mice in the large genetics laboratory of a Nobel Laureate Dr. Baltimore or a USGS scientist who falsified, or rather invented, studies on cobalt reserves in the US – the US is short of cobalt reserves which are needed for military steel applications. Cobalt its sources world wide are located in unstable or unfriendly nations) and continue to do so today (recent alterations of particle track data by physicists hoping for a Nobel Prize for discovering a new particle). Congress asked the National Science Foundation via its National Science Council of 12 selected experts to provide some ethical guidelines (Commission on Research Integrity). The summary is shown below.

> "It is a fundamental principle that scientists be truthful and fair in the conduct of research and the dissemination of its results. Violation of this principle is research misconduct. Specifically, research misconduct is significant misbehavior the fails to respect the intellectual contributions or property of others, that intentionally impedes the progress of research, or that risks

corrupting the scientific record or compromising the integrity of scientific practices.

Examples … include but are not limited to:

1. **Misappropriation**: An investigator or reviewer shall not intentionally or recklessly (a) plagiarize, which shall be understood to mean the presentation of the words or ideas of another as his or her own, without attribution… or (b) make use of any information in breach of any duty of confidentiality.
2. **Interference**: An investigator or reviewer shall not intentionally and without authorization take or sequester or materially damage any research-related property of another …"
3. **Misrepresentation**: An investigator or reviewer shall not with intent to deceive, or in reckless disregard for the truth (a) state or present a material or significant falsehood; or (b) <u>omit a fact so that what is stated or presented as a whole states or presents a material or significant falsehood</u> …"

The 3b errors of omission problems (data or conclusion cherry picking) are very common in science. The discussion section in most discussion in scientific paper ignores type 3b errors in their quest to justify the conclusions of the paper. The popular trend to mix results and discussions has made these 3b errors even more common since results (facts) can now be mixed willy-nilly with speculations (discussions). Thus it is not surprising to find that 3b errors crop up in reports such as those discussed in this review.

APPENDIX F
STAFF RESPONSES TO SCIENTIFIC PEER REVIEWER COMMENTS

Basin Plan Amendment for Methylmercury in the Delta
Response to Scientific Peer Review Comments

The June 2006 Delta Mercury TMDL Report and Draft Basin Plan Amendment Staff Report were submitted to two independent scientific peer reviewers in June 2006. The peer reviewers were asked specifically about the linkage between methylmercury in water and fish, staff's calculations of mercury loads, and likely effectiveness of the proposed implementation plan in reducing mercury in fish. They were also asked to comment on any other scientific issues of concern and whether the proposed regulations are based on sound scientific knowledge, methods, and practices.

Dr. Sedlak sent two letters. Dr. Horne's comments are in one letter. The complete letters from the peer reviewers and instructions to the reviewers are available at the Delta TMDL website:
http://www.waterboards.ca.gov/centralvalley/programs/tmdl/deltahg.html#Peer

Staff's summary of each reviewer comment is in bold text and is followed by the staff response.

<u>Dr. David Sedlak, UC Berkeley Dept. Civil and Environmental Engineering</u>
<u>Letter Dated 8 August 2006</u>

Comment 1. General Impressions
"Given the complexity of the problem and the difficulties associated with setting goals that are achievable, I believe that the staff members have used the available scientific data in a reasonable manner. Although I have some concerns about specific details, I have not found any major flaws that would call the scientific approach into question"

As Dr. Sedlak detailed his specific concerns in comments that followed, no response is necessary.

Comment 2. Proposed Basin Plan Amendment language pg. 5.
The proposed plan would require that all NPDES-permitted wastewater treatment plants (WWTPs) implement a pollution prevention plan. No scientific evidence is presented to support the idea that these programs will have a measurable effect on methylmercury discharged from WWTPs. Source control will likely reduce mercury in sludge produced in the treatment process, but not in effluent.

Staff recommended that pollution prevention plans be implemented to reduce total mercury discharged from WWTPs, rather than to reduce methylmercury discharges. A goal of the proposed Basin Plan Amendment is to prevent total mercury and methylmercury levels in the Delta from increasing while the methylmercury characterization and control studies are taking place. Pollution prevention plans can have a measurable effect on reducing total mercury in WWTP discharges. For example, according to recent Sacramento Regional County Sanitation District (SRCSD) information, the SRCSD Sacramento River WWTP has reduced its total mercury discharge between 2000 and 2005 by almost 50%. The California Department of Finance predicts that populations in the Delta and immediately adjoining counties will increase 60-120% by 2030, and 130-200% by 2050. Such population increases are expected to result in similar increases in WWTP effluent volumes and associated total mercury loads. Pollution prevention plans are a cost-effective way to help ensure that WWTPs maintain their discharge mercury levels as low as possible.

In addition, the requirement for WWTPs to implement pollution prevention plans is not new with this proposed Basin Plan Amendment. Section 13263.3 of the California Water Code states, "The Legislature finds and declares that pollution prevention should be the first step in a hierarchy for reducing pollution and managing wastes, and to achieve environmental stewardship for society. The Legislature also finds and declares that pollution prevention is necessary to achieve the federal goal of zero discharge of pollutants into navigable waters." Section 13263.3 also describes the conditions for requiring a pollution prevention plan, one of which is, “The state board, a regional board, or a POTW determines pollution prevention is necessary to achieve a water quality objective.” Because the Delta is listed as impaired by mercury on the Clean Water Act Section 303(d) List, Central Valley Water Board NPDES permit staff have included requirements for pollution prevention plans for mercury in recent permits for publicly-owned treatment works that discharge to or upstream of the Delta. Including the requirement for pollution prevention plans in the Basin Plan Amendment is a way to ensure that this practice continues.

Comment 3. Proposed Basin Plan Amendment language Table B.
“Is the percent reduction for the West Sacramento WWTP supposed to be 0% and not 100%?”

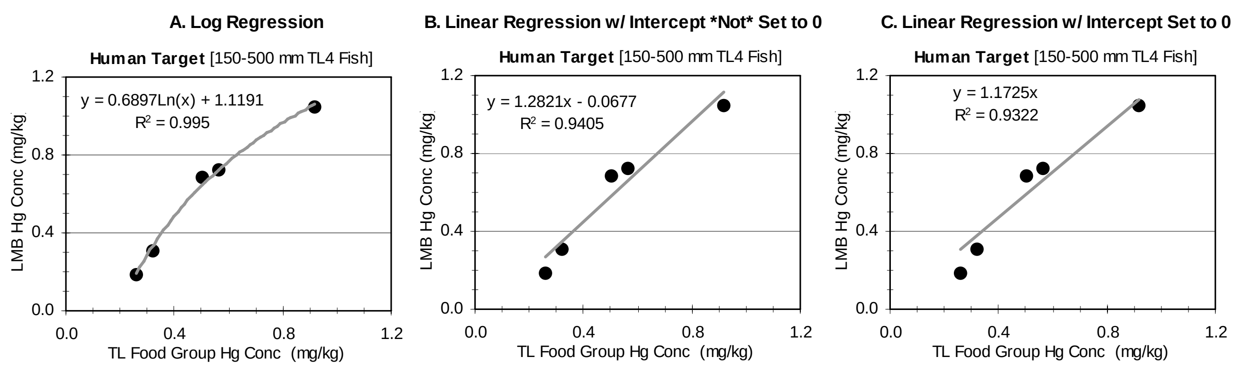
Yes. The percent reduction has been corrected.

Comment 4. TMDL Section 7.4.2 and Table 7.18.
Dr. Sedlak suggests that the staff report describe that elevated aqueous mercury concentrations (above the California Toxics Rule criterion for human health protection) are due to high total suspended solids in high flow events and that drinking water supplies are not threatened by mercury.

Staff agrees with Dr. Sedlak’s assessment that drinking water from the Delta is not unsafe due to mercury because most mercury, which is bound to particulates, would be removed in a drinking water treatment process. However, the health standards for mercury were developed to protect humans against exposure to mercury through drinking water and through consuming fish tissue. It is the latter of these two exposure channels that requires lower mercury limits due to the chemical’s bioaccumulative effects through the food chain. The analysis was conducted under the stricture of the more protective limit.

Comment 5. TMDL Section 4.8.3 and Figure 4.5. Staff used a linear regression equation forced through the origin to describe the relationship between mercury concentrations in trophic level 4 fish 150-500 mm in length and in largemouth bass. This is in contrast to the equations for relationships between largemouth bass and the other trophic level groups and size classifications, which were logarithmic equations not forced through the origin. There is no basis for forcing one regression through the origin but not the others.

Both logarithmic and linear curves intercept the x-axis above zero for the plot of mercury concentrations in largemouth bass versus the trophic level four 150-500 mm fish. This results in the prediction of near-zero or even negative values for some of the standard largemouth bass mercury concentrations that correspond to the alternative large TL4 fish mercury targets developed for human protection shown in Table 4.5 in the June 2006 report. Staff considered this situation to be a function of the trend lines tested and a lack of data for locations with very low fish mercury concentrations, rather than a true estimation of fish mercury levels. Therefore, a linear equation with the intercept forced to zero was used to estimate standard 350 mm largemouth bass mercury concentrations that correspond to the large TL4 fish target alternatives. All three regressions - logarithmic, linear, and linear with zero-intercept - are statistically significant (P<0.01). Staff added text to the TMDL report to better explain the basis for forcing the TL4-LMB regression through zero.



Comment 6. TMDL Section 4.7.2 and Tables 4.2, 4.3, and 4.9. The safe dietary values for snowy plover are different between these tables. Are the differences due to assumptions about lack of mercury in much of the snowy plover diet, which includes aquatic and terrestrial invertebrates?

Yes. 75% of the snowy plover diet is terrestrial mammal, bird, reptile, and invertebrate prey, which is assumed to contain negligible amounts of methylmercury. These assumptions are shown in Table 4.1. These parameters for the snowy plover diet were provided by the US Fish and Wildlife Service.[1]

While Table 4.2 indicates safe concentrations of methylmercury in the total diets of various wildlife species, Table 4.3 indicates the safe concentrations of methylmercury in various sizes of fish within these diets. Table 4.9 shows the predicted safe levels in large TL4 fish and standard size largemouth bass that correspond to the safe levels for various wildlife species. Dr. Sedlak is correct that the difference between total diet safe level (0.03 mg/kg, Table 4.2) and safe methylmercury concentration in trophic level 2 prey less than 50 mm (0.10 mg/kg, Table 4.3) is due to the composition of the snowy plover diet. The predicted safe levels in large fish that correspond to a prey concentration of 0.10 mg/kg that are shown in Table 4.9 are correct and come from the regression equations shown in Figures 4.2 and 4.5.

Comment 7. TMDL Section 4.5.3.1.
"I suggest that you show more than one significant figure on the example calculations of safe methylmercury concentrations to protect various wildlife species."

The calculations in Section 4.5.3.1 already use two significant figures for variables used in the equations (food chain multipliers and tropic level) and in the results. To improve clarity, staff added a second significant figure to the diet proportions and to the safe methylmercury concentration in TL3 fish for river otter. For example, 90% of TL3 fish in the diet is now shown in the equations as "0.90" instead of "0.9".

Comment 8.
Davis and Greenfield (2002) is missing from the TMDL reference list.

Staff updated the citation in the text and added the reference to the reference list.

Comment 9.
The proposed Basin Plan Amendment would require that wastewater treatment plants (WWTPs) that discharge to impaired subareas of the Delta reduce methylmercury in their effluent. Industrial users are not subject to the same restrictions because a comparison of intake and outflow data suggests that their activities do not increase methylmercury concentrations. The TMDL should treat the industrial and municipal dischargers in a similar manner. If you apply the same inflow/outflow comparison to WWTPs, then a WWTP that discharges a lower concentration of methylmercury than in its raw source water should be given credit for the decrease.

The five power and heating/cooling facilities in the Delta use ambient water for cooling. Based on the comparison of available intake and outflow methylmercury data (TMDL

[1] USFWS, 2003. Evaluation of the Clean Water Act Section 304(a) Human Health Criterion for Methylmercury: Protectiveness for Threatened and Endangered Wildlife in California. US. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Environmental Contaminants Div. Sacramento, CA.

Section 6.2.3 and TMDL Appendix Table G4), these facilities do not appear to act as a source of new methylmercury to the Delta.

Staff changed the proposed Basin Plan Amendment language to assign aqueous methylmercury allocations to all NPDES-permitted facilities, including power and heating/cooling facilities (Table B of the proposed Basin Plan Amendment). Table 4.6 of the Basin Plan Amendment staff report identifies the various types of facilities (aquaculture, manufacturing, power, publicly owned treatment works, etc) in the Delta.

Dr. Sedlak suggests that a WWTP that discharges less methylmercury than it takes in be given credit for the decrease. In response, staff compared methylmercury concentrations in source water and effluent for various Delta facilities and considered whether credits would be possible under existing policies. At this time, the Regional Board does not have a framework for offering methylmercury discharge credits that could be traded or banked against future expansions. In the proposed Basin Plan Amendment (Table B), many WWTPs discharging directly to the Delta are assigned a zero percent reduction in methylmercury loads, either because they discharge to an unimpaired area of the Delta or because their discharge concentration is less than the aqueous methylmercury goal. Thus a credit would not be needed. Staff will consider credits as a possibility for future policy development with offsets in Phase 2 of the implementation plan, or future TMDLs.

Comment 10. TMDL Section 7.1.4.
The discussion of dry deposition of mercury included the statement, "…mercury may be more or less easily transported than water once it comes in contact with land surfaces." The possibility that mercury could be more easily transported than water does not make a lot of sense. Is this a misstatement?

This was a misstatement. The paragraph has been revised and simplified (pg. 117 in Peer Review TMDL Draft Replacement Chapter 7).

Comment 11.
In Tables 8.3 a-g, I believe that the column headed "Acceptable MeHg concentration" should have units of ng/L and not g/yr.

Staff corrected Tables 8.3a-g.

Comment 12. TMDL Appendix J Regressions of flow versus mercury concentration.
"The conclusion that all of these regressions are significant is questionable. For example, the Feather River graph shows about 30 data points with flows less than 30,000 cfs and three with higher flows. Without the three higher points, I suspect that there would not be a significant relationship (i.e., it would look like a scatter plot). Simple linear regression models assume equal spacing of data and these regressions may be biased by a few high flow observations. It may be necessary

to consult a statistician about the need to weigh the data to avoid bias or to identify other ways to test the significance of putative relationships".

Staff used the available data for calculation of the mercury/TSS to flow relationships. Staff agrees that the R^2 values for the regressions of total mercury versus flow for some tributaries, particularly the Feather River and Colusa Basin Drain, are relatively low. When there were enough data points to be statistically significant, staff preferred to use the regression equations to estimate loads rather than multiplying flow by an average mercury or TSS concentrations. We have attempted to address the issue of fewer points at high flow events by planning the collection of more concentration data at high flows. When available, this data should lead to a more accurate characterization of the rating curves. It is useful to note that this is a TMDL for the Delta. Information on mercury loads from tributaries is provided to help readers understand where the mercury originates and to guide future studies. Newer data will be incorporated in the TMDLs for the tributaries.

Staff consulted with a statistician on staff at the University of California, Davis, for a review of the methods used in calculating mercury and TSS loads and for guidance on calculation of confidence intervals. This information, in the form of revised TMDL Report Chapter 7 and Appendix J, was provided to the scientific peer reviewers several weeks after the initial review package. The UC Davis statistician confirmed staff's use of the regression equations to calculate loads when the regressions were statistically significant.

Tables 7.1, 7.3, 7.4, 7.6b, 7.6c, 12, 14 and 16 in the revised Chapter 7 show the completed 95% confidence intervals for the total mercury and suspended sediment load estimates and for the Delta and Sacramento Basin mass budgets. The method of calculating the confidence intervals is provided in the revised Appendix J.

One purpose of the confidence intervals is to allow staff to determine whether the Delta and Sacramento Basin total mercury and sediment budgets "balance" (i.e., whether there is a statistically significant difference between the inputs and exports) and to formulate recommendations for compliance with the San Francisco Bay mercury TMDL allocation for the Delta. Table 7.14 shows estimates of Delta exports to San Francisco Bay from the TMDL, a separate Central Valley Water Board report, the San Francisco Bay TMDL, and the San Francisco Bay Regional Monitoring Program. For the Delta TMDL, Staff calculated confidence intervals around the TMDL's estimates of mercury exports from the Delta to the San Francisco Bay at X2 and compared these values with estimates by others of mercury exports at Mallard Island. Staff noted that considerable variation is present in the various estimates made for Mallard Island and X2, even for the same six-year period. The confidence intervals for the mercury loads at X2 calculated by staff were broad and overlapped the range for Mallard Island mercury loads provided in the San Francisco Bay Mercury TMDL. Central Valley Water Board staff concluded that unless a consensus is reached on the 20-year mercury export rates at Mallard Island, compliance with the San Francisco Bay mercury allocation to the Central Valley is best determined by monitoring mercury inputs to the Delta.

Dr. Sedlak's Letter Dated 6 September 2006

Comment 1.
"The first scientific question is related to whether available data can be used to accurately determine the contributions of methylmercury from managed wetlands, agricultural runoff, and urban runoff. …The estimates of loading from these three classes of methylmercury sources are based on a very limited data set and have considerable uncertainty. Therefore, I agree with the staff's decision to require the collection of additional data to obtain better estimates of the loading from non-point sources. …To increase the likelihood that the data will be useful to future load estimates I suggest that any additional plans for data collection be subject to peer review."

Staff appreciates the suggestion that plans for the characterization and control studies be subject to peer review. To the extent possible with funding constraints, staff agrees that plans should be peer-reviewed. The Basin Plan amendment now recommends that staff form an independent/external technical advisory committee to review study designs and results. Data collected as part of a CALFED Ecosystem Restoration Program project may be subject to peer review through the CALFED Science program. Furthermore, all future Basin Plan amendments will be subject to the same peer review requirements as this one, as required by Californian Health & Safety Code § 57004.

Comment 2.
"I agree with the staff that there currently is not enough information to design effective control strategies or to estimate the costs of such strategies. …At this point, it is difficult to know if methylmercury production really can be minimized by wetland designs. …Without additional research, it seems likely that the only control strategy for methylmercury in restored wetlands would be not to restore wetlands. If this is the effect of requiring that restored wetlands do not increase methylmercury loadings, I believe that this decision should be made in light of the benefits to the ecosystem associated with habitat restoration."

The proposed methylmercury control program does not require any methylmercury reductions from restored wetlands during the Phase 1 characterization and control study period. Recent studies reported at the 2006 CALFED Science Conference (http://science.calwater.ca.gov/conferences/sciconf_index.shtml) suggest that different types of wetland habitats produce varying amounts of methylmercury. The proposed Basin Plan Amendment recommends that any new information be incorporated into new wetland and restoration projects.

Comment 3.
"I agree with the staff that the planned collection of data on methylmercury concentrations in agricultural drains and [storm water] runoff will be useful to establish a mass balance. However, I am uncertain that cost-effective

approaches for reducing methylmercury concentrations will be developed during the study period. It is likely that any approaches that are developed will be limited to specific types of soils and crops, thereby necessitating site-specific studies prior to selection of control approaches. Likewise, quantification of mercury and methylmercury in storm water is likely to be challenging due to the potential for sample contamination and the variability of flows within storms.

Comment 4.
"In conclusion, I believe that the staff has employed a sound approach to implementing the TMDL in a stepwise fashion that is consistent with the principles of adaptive management, which was recommended by the National Academies in their review of the TMDL process. After completion of the studies it is likely that the staff will be in a better position to assess methylmercury loading and the costs associated with control activities. However, the estimates of methylmercury loads from these sources and the cost effectiveness of various control strategies will always have considerable uncertainty.

No further response is necessary. Staff thanks the reviewer for his comments.

Alex Horne, UC Berkeley Professor Emeritus, Ecological Engineering, Dept. Civil & Environmental Engineering

Comment 1. Loss of Delta Habitat.
"The overriding ecological need in the Delta is to restore as much habitat as possible to its original tidal wetland state. …Although the restoration of the Delta is not the Board's main responsibility, in its MeHg TMDL addendums proposal the single-minded pursuit of mercury control threatens Delta restoration. In effect, the TMDL will throw the baby (the Delta) out with the bathwater (excess MeHg)." Because sources of inorganic mercury from the Coast Range, Sierra streams, and atmospheric deposition are unlikely to be reduced very much in the next 50 years, excess methylmercury will continue to be produced in wetlands. Restoration of wetlands will be effectively prevented because the Board has not guaranteed that adequate offsets will be available to be used by wetlands projects.

The reviewer does not agree with the proposed implementation plan because the reviewer believes that regulation of mercury is of secondary importance compared to wetlands restoration. Dr. Horne suggests that the regional staff table the mercury TMDL project and instead devote their resources to wetlands restoration. However, the regional board is committed to reducing the levels of toxic MeHg through the TMDL process to address the continued impairment of the Delta water system.

The reviewer recognizes that wetlands are noteworthy sources of methylmercury and is concerned that this characteristic might hamper future wetlands restoration projects if the draft Basin Plan is adopted. Staff realizes that more information is needed about effective ways to control methylmercury from various sources, including wetlands. Staff proposes that dischargers specifically not be required to meet the methylmercury allocations until the proposed Characterization and Control Studies are completed. At the end of the study period, the Central Valley Water Board would review any new information and adjust the program of implementation, including methylmercury allocations, as necessary.

Concern with methylmercury and wetlands restoration projects in the Delta is not new. The CALFED Water Quality Program Plan (July 2000) calls for monitoring of mercury and methylmercury during and after remediation and development of remediation options that address mercury loading, transport, transformation, or bioavailability. This CALFED plan also states that an ultimate goal should be the lifting of fish tissue advisories and the elimination of the need for new ones. The CALFED Bay-Delta Program Record of Decision (ROD) preferred option includes significant restoration of wetlands in the Delta. The ROD Appendix A, "Mitigation Measures Adopted in the Record of Decision" (August 28, 2000), describes potentially significant environmental impacts resulting from adoption of the preferred Plan, including an increase in methylation of mercury in constructed shallow-water habitat. The CALFED ROD Appendix A also describes mitigation measures to reduce potential effects of implementation of the Preferred Program Alternative on water quality, including “test for mercury in soils and locate constructed shallow-water habitat away from sources of mercury until methods for reducing mercury in water and sediments are implemented.” The California Environmental Quality Act Findings of Fact contained with the CALFED ROD (ROD Attachment 1, August 28, 2000) state, “The bioaccumulation of toxic methyl mercury in food webs can impact consumers of aquatic organisms, specifically through the consumption of fish caught in the Bay-Delta. This impact is considered significant.” Probably not all Delta wetland restoration projects will be performed under the CALFED program. However, those that are planned under CALFED need to consider the impact methylmercury, even without the Delta TMDL.

The reviewer is concerned that the Central Valley Water Board has not guaranteed that adequate offsets will be available. In the proposed Basin Plan Amendment language, staff strengthened the Board’s commitment to consider offset pilot projects and lengthened time for developing an offset program. The proposed Amendment includes the following:

> By [8 years after adoption of the Amendment], the Regional Board intends to consider adoption of an offset program to allow dischargers to offset methylmercury and/or total mercury in their discharges by implementing more feasible or cost effective projects elsewhere in the watershed. The offset program will be consistent with any State Board offset policy that is developed. In the interim, the Regional Board will allow all mercury and/or methylmercury dischargers to conduct pilot offset projects. The pilot offset projects could achieve one or more of several goals: accomplish early implementation of mercury reduction projects; provide information that can be used to develop the Phase 2 offset program; and/or earn credit to offset methylmercury allocation and/or total mercury limit requirements during Phase 2 of the Project. To be most useful, the pilot offset projects should focus on projects that can be implemented relatively quickly.

“The obvious scientific solution is to balance the potential harm of MeHg production in wetlands with the certain large ecological benefit of these wetlands. Urgently needed is a trade (offset) between wetlands restoration benefits and MeHg production. The Board only offsets like with like (i.e., not mercury with, for example, increase in habitat area.) It is not sound science to restrict the certain benefits of restoration of the Delta for possible harm caused by low levels of MeHg.”

The federal Clean Water Act requires that States list water bodies that do not meet water quality standards (i.e., are impaired) and develop programs to correct the impairment. Federal law does not give the State license to allow the methylmercury impairment to remain or worsen in trade for other environmental improvements. The overall requirement of reducing methylmercury is thus established. However, the Central Valley Water Board does have flexibility in deciding how the methylmercury reductions will be achieved. If presented with convincing evidence that lack of or delay in restoration of wetlands causes harm to habitat or sensitive wildlife species, the Board could adjust the allocation scheme. Staff agrees that there needs to be a balance between reducing methylmercury produced by wetlands and protecting ecological benefits provided by wetlands.

Dr. Horne describes the levels of methylmercury in the Delta as “low”. However, there is a consumption advisory regarding eating sturgeon and striped bass from the Delta. The California Office of Environmental Health Hazard Assessment recently released a draft of safe eating guidelines for other Delta fish species. In surveys of consumers of Delta fish, the Department of Health Services Environmental Health Investigations Branch has found that people routinely eat Delta fish, of these and other species, in excess of the safe human intake level of methylmercury (USEPA’s methylmercury reference dose). Thus far in wetlands restoration, there has been little attention given to methylmercury production. While ecological and human benefits of wetlands are being realized, the human health risk of methylmercury must not be ignored and should be minimized. In addition, methylmercury risks to Delta wildlife are still presumed to occur. Although Delta-specific exposure and effect studies for wildlife are lacking, concentrations of methylmercury measured in Delta fish are above levels observed in field and laboratory studies elsewhere that harm wildlife species.

Comment 2. Arbitrary decisions.
“Not enough is understood about the environmental chemistry of mercury in the Delta to make informed scientific decisions (for example what controls MeHg in wetlands). …In the work of my own group at UC Berkeley we have found that iron and redox are also important (these factors are not considered in the TMDL documents provided suggesting 3b errors and incomplete rather than unsound science).”

Staff’s intention in Chapter 3 was to highlight factors important in methylmercury production that are potentially controllable in the Delta, which included sulfate, new water impoundments and wetlands, and inorganic mercury. Staff recognizes that other factors, including pH, iron, activity of methylating bacteria (iron-reducing or sulfate-reducing), percent and type of organic material, and redox state can also affect methylmercury production. These factors were not considered controllable in the Delta and were not discussed in detail. Staff appreciates the suggestion to include iron and redox in the discussion of factors affecting mercury methylation.

“My view is that making detailed plans for allocations of MeHg loads are thus premature until more is known about how to construct large seasonal and permanent wetlands that do not produce very much MeHg. More logical at this time would be an attack on the known main sources that are understood (old mines, sediment from these mines, other external sources) since the chemistry and hydraulics of these large sources is known.”

Staff agrees that more information is needed about design and operation of wetlands that minimize net methylmercury production or export. That is why staff proposes that dischargers not be required to meet methylmercury allocations until further studies are completed. It may seem premature, then, to include methylmercury allocations in the proposed Basin Plan Amendment. However, federal regulations require that a TMDL include wasteload allocations for point sources and load allocations for nonpoint sources. Staff changed the proposed Basin Plan language to make it clear that the Central Valley Water Board intends to reevaluate the allocations and program of implementation after the characterization and control studies are completed. The allocations will guide the characterization and control studies, in terms of identifying subareas that need the greatest reductions and thus effort toward developing management practices. Nonpoint and point source dischargers will be involved in determining where characterization and control studies should occur and will have primary responsibility for developing study work plans.

Staff also agrees that sources of inorganic mercury, which are mainly upstream of the Delta, should be addressed in order for a control program to be effective. These sources are not ignored. The proposed Basin Plan Amendment assigns a total mercury load reduction to Cache Creek exports and requires improvements in the trapping efficiency of the Cache Creek Settling Basin. Cache Creek contributes about 30% of the mercury load from the entire Sacramento River Basin. The proposed Basin Plan Amendment also requires controls on mercury from point sources (wastewater treatment facilities and storm water systems) that discharge to the Sacramento River, San Joaquin River, and other tributaries downstream of major dams. These waters are the focus of the next set of TMDLs to be developed by the Central Valley Water Board, which will assign additional total mercury load reductions.

Mercury reductions upstream are also being accomplished separately from the Delta TMDL. For example, the Cache Creek Watershed TMDL required that 14 inactive mines be remediated to pre-mining conditions with respect to mercury discharges. Under an emergency response action, the USEPA is currently directing the cleanup of the two largest of those mines, which are on Harley Gulch. The USBLM, the USFS, and the USEPA have brought about cleanups at several sites highly contaminated with mercury in the Bear and Yuba River watersheds, including Polar Star, Sailor Flat, and the Boston Placer Mine. State Water Board staff has performed a pilot project that removed elemental mercury by suction dredging at an in-channel “hot spot” in the American River. As described in the TMDL report, though, mercury is nearly ubiquitous in tributaries that hosted mercury or gold mining. Cleaning up hundreds of sites where mercury was mined or used is a lengthy process. It will take even longer for mercury that has become distributed in streambeds and banks to be removed.

Comment 3. Mass Balance Concerns. The main strategy of the Board for all but the smallest entities is to offset any of their MeHg in other Delta areas. This provision is important for large, uncontrolled wetlands, such as Yolo Bypass wetlands. As more such large wetlands are restored in the Delta, it is not clear that there is sufficient offset available. If non-similar offsets were allowed (Comment 1), this would not be a concern.

Staff agrees that as more wetlands are restored, there may not be sufficient methylmercury reductions being achieved elsewhere to offset the increased methylmercury loads coming from new wetland projects. This dilemma emphasizes the need for more studies on how to control methylmercury and attention to design and timing of new projects so that methylmercury from new projects is controlled.

Staff proposes a mercury management strategy that relies first on a study period that will refine the estimates of methylmercury loads and test possible management practices. Identification of management or land use practices that can limit net methylmercury production will aid in identifying possible offset projects.

The peer review version (June 2006) of the proposed Amendment stated that staff would develop a mercury offset program for Central Valley Water Board consideration in 2009, which is a relatively short time for identification of possible offsets. Staff adjusted the proposed Basin Plan Amendment language to make it clear that the implementation plan, including allocations, will be reconsidered after the study period. The revised Amendment proposal states that an offset program will be proposed at the end of the study period and allows dischargers to participate in a pilot offset program, if desired, until a full offset program is developed. Offsets are just one tool for addressing "uncontrollable" methylmercury from wetlands. Timelines and allocations to other sources may also be adjusted to enable increased wetland methylmercury loads. However, if gradual reduction in total mercury concentration of incoming sediment is considered the only feasible method of controlling a wetland methylmercury load, then the timeline to meeting the allocation would be lengthened, prolonging the methylmercury risk to humans and wildlife. Note that the State Water Board remanded the San Francisco Bay mercury TMDL to the San Francisco Bay Water Board for further consideration in part to accelerate achievement of fish tissue objectives for mercury in the Bay.

Again, staff agrees with the need to balance benefits and disadvantages of wetlands restoration. Staff's responses describe ways this can be done. A formal offset program that addresses both methylmercury loads and ecological benefits, though, is complicated to design and implement. An offset program should have a clear, quantitative method for evaluating the items to be traded. Staff expects that it would be very complex for stakeholders, the Central Valley Water Board, and other agencies that must approve an offset program, to agree upon a method for trading non-similar outcomes, such as increased methylmercury in fish eaten by one wildlife species allowed in trade for increased habitat for another.

Comment 4. Unethical Scientific Practices.
In a work this large, unethical scientific practices are likely and are normally easily corrected. "In this report, the usual POBs (positive operator bias) occurred in terms of always choosing the most conservative value rather than a mean or representative values. …[T]he assumption that 100% Hg in fish is MeHg for purposes of monitoring rather than the average of 85-100% as was found in the data is one example of POB. The 3b errors [errors of omission or 'cherry-picking

data'] are harder to detect but the mitigating effects of Se on MeHg toxicity and the lack of evidence of MeHg toxic effects in currently high MeHg areas are two examples."

In the technical analyses and proposed implementation plan, Staff endeavored to take an approach supported by the science and did not purposely select the most conservative value or approach. Staff responded to the examples cited by Dr. Horne.

1) Percentage of methylmercury in fish. The fish tissue objectives are for concentration of methylmercury in fish tissue. The proposed Basin Plan Amendment does state that, "total mercury may be analyzed instead of methylmercury". This is commonly done in fish issue monitoring programs for water quality investigations and consumption guidance to reduce cost of analyses. Because the methylmercury/total mercury ratio in some fish is essentially 100%, it would not be appropriate to apply a corrective factor to the fish tissue concentration used in the linkage analysis (the linkage analysis relationship sets the aqueous goal, from which the allocations are determined). If there is uncertainty or concern about the methylmercury/total mercury ratio when the Delta fish tissue objectives are close to being attained, the Central Valley Water Board could require fish samples be analyzed for methylmercury instead of total mercury.

2). Selenium. No error was perpetrated by not mentioning the sometimes-protective effect of selenium (Se) on methylmercury toxicity. Staff has no evidence that Se that occurs naturally in the Delta is protective for humans eating fish. Staff agrees that studies with wildlife exposed to Se and methylmercury have shown mitigating or protective effects of Se. However, not all studies show Se to be beneficial.

3). Lack of data. The absence of data in the TMDL report showing adverse effects of methylmercury where concentrations are high is not an example of "cherry-picking data". Although highly desirable, studies of effects of methylmercury exposure have not been conducted in the Delta. The Numeric Target section of the Delta TMDL report briefly describes toxic effects of methylmercury observed elsewhere. More information is available in the TMDL report citations and the Clear Lake Mercury TMDL Numeric Target Report (available at: http://www.waterboards.ca.gov/centralvalley/programs/tmdl/clearlake.html). The Department of Health Sciences Environmental Health Investigations Branch has documented high rates of fish consumption by some people in the Delta, which very likely puts them over safe methylmercury intake levels. Verifications of their exposure through biomonitoring and effects studies have not been completed. At the Fall 2006 CALFED Science conference, researchers from the USFWS and USGS presented data about bird populations in San Francisco Bay adversely affected by methylmercury (Woo, Takekawa, and Tsao-Melcer on black rails; and Ackerman, Eagles-Smith, Adelsbach, and Yee on Forsters' terns; Abstracts available at: http://science.calwater.ca.gov/conferences/sciconf_abstract.shtml). If data for humans or wildlife that consume Delta fish become available, staff will incorporate them into the implementation plan.

"The main unethical problems do not appear to be the work of the Board's staff but in the work on which they have relied, especially the mercury toxicity studies of the USFWS (the key to the entire Board calculations appears to be a study on mink and mercury carried out by the USFWS to establish a baseline for mercury concentration vs. health effects). I have not reviewed this secondary work here since it was not in the mandate. However, in my reviews of this agency's work in the past I have found that the USFWS does not have a policy to remove Positive Operator Bias and type 3b errors which are thus often rife.… if [the USFWS] work could be validated by a more reliable non-agency study I would feel more comfortable about the compromise that would be made if a lower Hg standard was applied to the Delta."

Dr. Horne's observations of unethical scientific practices in USFWS work in other fields cause him to question the methylmercury safe levels for wildlife. Staff used these levels in its evaluation of fish tissue objective alternatives. Staff has two responses.

1). The recommended methylmercury fish tissue objectives for large fish are the levels needed to protect people eating eight ounces uncooked Delta fish per week. These recommended objectives are lower than the protective values for wildlife eating large fish (otter, bald eagle, and osprey). Although Staff recommends a small fish objective that is based completely on wildlife needs, the aqueous methylmercury level needed to reach the large fish human-health objective is lower than the aqueous methylmercury level needed to reach the small fish objective. Thus, human safe levels, not wildlife, drive the methylmercury allocations. The Delta TMDL Report Table 4.9 shows all of the wildlife and human health safe fish tissue levels and the corresponding values in terms of the 150-500 mm trophic level 4 fish concentration average and the standard 350 mm largemouth bass concentration. Wildlife safe methylmercury levels are less stringent than levels needed for human consumption of 8 ounces of Delta fish per week.

2). The wildlife toxicity studies, reference dose, and the methodology used by the USFWS to calculate safe methylmercury levels in aquatic prey are published in the USFWS' evaluation of the USEPA's methylmercury human health criterion. This USFWS report was peer reviewed by external, independent scientists. The independent reviewers supported the USFWS' selection of toxicity studies, reference doses, and methodology. The USFWS report and its external review are available at: http://www.fws.gov/sacramento/ec/bio-monitoring.htm.

Staff also notes that the studies upon which the mammalian and avian references doses were based (studies in mink and mallards, respectively) were conducted by researchers not associated with the USFWS and were published in peer reviewed, scientific journals.

Comment 5. Fossilized standards.

"The report is written as if future flexibility can occur in standards. This is not likely and has become a huge flaw in the scientific part of the standard setting mechanism in California and the US as a whole. …Compromises [of making

decisions on available data that may change] are inevitable but experience has taught us that it is virtually impossible to modify standards or Basin Plan Objectives even if the future scientific evidence is overwhelmingly in favor of changes. Although the understanding of copper toxicity in San Francisco Bay changed, water quality objectives there remained for more than 25 years. Will this happen with methylmercury in the Delta? The emphasis on the wrong toxicant or form of toxicant has considerable ecological costs since funds wasted could be spent on real toxicity problems or habitat improvements."

Staff agrees that changing fish tissue objectives or other Basin Plan components can be a difficult or lengthy process. Uncertainty about how best to control methylmercury is exactly why Staff recommends a study period and reevaluation of all Basin Plan components before modifying the control program. As described in the response to Comment 1, the proposed Basin Plan Amendment commits the Board to this reevaluation, including changes to allocations if data support the changes.

Comment 6. A New Paradigm for Pollutant Trading
This comment elaborates on the idea of using unlike currency in a methylmercury offset program. For example, the Yolo Bypass and other wetlands to be created to restore the original Delta are a large environmental good. Farms also are a social good. Both wetlands and farms may increase methylmercury. To remove these wetlands or farms or require them to pay for mercury cleanup upstream is bad for the Delta. The Board must use science to balance the good of wetlands or farms against the harm of methylmercury production. Dr. Horne describes a trading system that he suggested to the Santa Ana Regional Board of allowing some increase in nitrogen and phosphorous loads in Lake Elsinore for increasing the water level during dry periods.

Dr. Horne is concerned that by focusing on methylmercury reduction, that Delta restoration and farming will be harmed. Staff agrees that this is a valid concern. The proposed Basin Plan Amendment does not suggest that farms or wetlands be removed. Staff also agreed with his statement that the Board must use good science in making its decisions. To this end, Staff has endeavored to provide as scientifically valid an assessment of the methylmercury concerns as possible. In order to consider trading habitat for methylmercury reduction, studies must be completed that conclusively show that wildlife species using the habitat are not harmed by the methylmercury. Such effects studies are lacking for the Delta. Please see response to Comment 3 for other thoughts about offsets.

Detailed Comment A. The Water Quality Objective Option #4 is chosen.
"As described elsewhere any option that reduces the likelihood of the recreation of tidal and other wetlands in the Delta is self defeating. The wildlife may be totally free of possibly toxic methylmercury, but that will not matter. There will be no wildlife to save. The reality is that several million of the 20 million more Californians that will be in the state in 2050 will live in and around the Delta. Without a lot of larger new wetlands the wildlife will vanish. Thus the MeHg

standard should take note of the changed environment. Suggestion. Go with the No Action alternative at this time with provision to reduce the Cache Creek and upstream mercury. Intensify research on how to run wetlands to give lower MeHg outputs."

Staff's response has several parts. First, fish tissue objective alternative 4 is not yet chosen. The peer reviewer read Staff's recommendations. The Central Valley Water Board will make its decision at a public hearing. Second, the fish tissue objectives must be protective of the uses of the water to which they are applied. In this case, they must protect wildlife and humans consuming Delta fish by using the best available science for determining the safe levels. Issues like cost and future population pressures in the Delta are not priorities in the objective setting process. Third, the flexibility that Dr. Horne seems to request lies in the implementation plan choices. The draft Basin Plan Amendment Staff Report describes many implementation considerations and options, ranging from whether the plan should address methylmercury as comprehensively as possible by including wetland and farm sources or whether it should rely only on total mercury and take many more generations to achieve safe fish levels in the Delta. Even the California Bay-Delta Authority, which is funding much of the Delta restoration, identified methylmercury as a potentially significant impact that should be mitigated and has called for studies (see response to Comment 1). Staff deemed it worthwhile to call for methylmercury reduction studies from all source categories before determining at the end of the Implementation Phase 1 review period that methylmercury reductions are too costly or infeasible. Provisions to reduce total mercury loading, including from the Cache Creek Settling Basin, are included in the proposed implementation plan. Fourth, the reviewer comments on the Delta's future, both in terms of effects of the proposed methylmercury Basin Plan Amendment and planning for expected population increases. Staff fully agrees that both should balance habitat and protection of Delta wildlife.

Detailed Comment B. Anoxia (redox) in the sediments as a cause of methylation. "I was surprised that anoxia was not considered in the conditions controlling MeHg production. Since the addition of oxygen even at levels of 0.1 mg/L is an experimentally demonstrated method to prevent methylation it is obviously of concern in the Delta. It is also a potentially controllable situation in some areas including wetlands that are so important in in-Delta MeHg production. Oxygenation of water is a simple and inexpensive process and can be increased in wetlands by the choice of plants and hydroperiod. Suggestion: Add the role of oxygen to the appropriate section and consider solution to methylation in Delta habitats at risk."

Thank you for the suggestion to add a discussion about oxygenation to the report. See also response to Comment 2. Through Proposition 40 bonds, the State Water Resources Control Board recently funded the Department of Fish and Game Moss Landing Marine Laboratory and the US Geological Survey to conduct an in-depth study of methylmercury production in seasonal and permanent wetlands and rice fields in the Yolo Bypass. The study will include comparisons of plant effects on methylmercury.

When talking to proponents about management practice studies and pilot projects, staff will discuss plant selection, oxygenation, and wetland flow regime as variables that could be evaluated.

Detailed Comment C. "Piscivorous fish are assumed to obtain all aquatic prey from the local water body so no relative source contributions are used. Unless I have misunderstood the sense or the report, this is an example of positive operator bias (POB) and possible type 3b ethical error ("cherry-picking). The POB is that most birds move over days and seasonally. They may feed on MeHg contaminated food one day and uncontaminated food on the next. This kind of migration bedevils field toxicity studies by must be accounted for. The possible 3b error is that these feeding studies are very likely to be available elsewhere suggesting cherry picking of the data to support lower Hg standards than scientifically justified."

Please see response to comment 4. The wildlife safe methylmercury levels do not drive the proposed fish tissue objectives or the aqueous methylmercury goal. Therefore, even if the wildlife safe levels were higher to take into account a relative source contribution, the recommended implementation plan and allocations would not change. As the reviewer noted, the recommended fish tissue objectives do not even fully protect human Delta residents who consume large amounts of locally caught fish (Dr. Horne's original letter page 3 comment 5 line 7). The implementation plan aside, Staff agrees that it would be useful to be able to fully estimate a migratory bird's methylmercury intake. This is a complex task. Although type of prey information is often available, one also needs the consumption rates by season or stage of life cycle (e.g., is the bird increasing intake in preparation for migration?), body weights, methylmercury concentrations in the prey, and methylmercury excretion rates by life stage (e.g., how much is the bird depurating into eggs or feathers?). In six years of work on methylmercury targets, Staff has not seen this kind of detailed analysis advanced for any wildlife species.

Detailed Comment D. USFWS guidance to the Regional Board on exposure parameters. "This reviewer is not privy to these guidance parameters but past experience with the USFWS in the Central Valley indicated that POB and type 3b errors are common in USFWS reports. Sound science cannot operate in the opaque conditions."

Please see response to Comment 4.

Detailed Comment E. Dilution of MeHg with increased biomass. "In a recent MeHg project in which I was involved (Lake Onondaga, New York), the restoration of the biota was considered to dilute the available MeHg. The situation is the same in the Delta. The Hg inputs are constant or declining. Thus if more wetland and more wetlands biota are created the MeHg/individual will decline. In addition, some Hg may be stored permanently in deeper sediments of the wetlands where it is biologically unavailable. Suggestion: Calculate the dilution and use the

factor obtained to monitor the biota to determine if the proposed standards can be lessened."

Staff is familiar with the idea that an increase in phytoplankton occurring with a static amount of methylmercury will dilute the concentration per unit of plankton, which will reduce the amount of methylmercury eaten per unit prey through the food web. The much larger, diverse Delta, however, may not act like Lake Onondaga. It is staff's understanding that restoration of some wetlands will involve seasonal or permanent flooding of land that has been not flooded since the advent of agriculture and development in the Delta. Flooding of land that is not currently inundated will most likely increase the methylmercury load to the Delta. It is difficult to predict whether an increase in biota from restored habitat will dilute the increased methylmercury. Research by Central Valley Water Board Staff has shown that wetlands can have concentrations of methylmercury 1-2 orders of magnitude higher than adjacent drainage ditches or open water. In contrast, some wetlands, particularly tidally-influenced ones, have little effect on methylmercury loads in downstream water (See CALFED 2006 Science conference abstracts by J. Fleck and M. Stephenson, available at: http://science.calwater.ca.gov/conferences/sciconf_abstract.shtml). Increased biota might have a diluting effect in the Delta, but it is too early to assume that it will occur.

Staff thanks the reviewer for his comments.